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# SAFETY, HEALTH AND ENVIRONMENT (SHE) MANAGEMENT IN A LARGE MODERN NITROGENOUS FERTILIZER COMPLEX - NFCL'S APPROACH

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## *RESUME*

*NFCL exploite un complexe moderne de production d'ammoniac-urée à base de gaz naturel à Kakinada, Inde. Les systèmes et méthodes de NFCL pour la gestion de la sécurité, la santé et l'environnement sont traités. La mission du groupe est de « servir la société à travers l'industrie » et le fondateur M. K.V.K. Raju pensait que la responsabilité sociale d'une entreprise doit aller bien au-delà des limites de la conformité avec les réglementations statutaires.*

*Conformément à cette philosophie, la protection de l'environnement a été considérée dès le stade de la conception et un programme intégré de gestion de l'environnement a été mis au point pour obtenir un rejet zéro d'effluents à l'extérieur du complexe. Une détermination de l'Impact sur l'Environnement (EIA) a été effectuée au stade de l'avant-projet et, sur la base des constatations de l'EIA, un certain nombre de traitements des effluents liquides et gazeux et des mesures de contrôle ont été mis en oeuvre dans les unités. On a aussi veillé à maîtriser les émissions fugitives. Un vaste espace vert deux fois plus grand que la surface de l'unité a été créé autour du complexe en utilisant la sagesse et l'expertise combinées de meilleurs spécialistes de diverses disciplines et impliquant des efforts considérables. Des stations automatiques ont été implantées pour contrôler la qualité de l'air et des paramètres micro-météorologiques autour de l'usine.*

*Récemment, la société, en plus de recevoir la certification ISO 9002 par BVQI, Pays-Bas a eu la distinction de recevoir le prix de l'Association indienne des fabricants de produits chimiques pour les stratégies de contrôle de l'environnement et la sécurité dans les usines chimiques, le prix national de la sécurité pour 1994 du Conseil britannique pour la sécurité et le prix national 1995 de la qualité du Paon d'Or.*

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## INTRODUCTION

Nagarjuna Fertilizers and Chemicals Limited is part of the Nagarjuna Group of companies which is a fast growing and well diversified group in India. The group was founded in 1974 by late Mr. K.V.K. Raju, a technocrat entrepreneur and is now divided into four business sectors: steel, agri-business, financial services and power. The group is now engaged in a major expansion exercise - doubling the capacity of its ammonia-urea complex at the existing site at a cost of US $ 280 million and setting up an integrated 2.5 million tonnes steel plant and a 1000 MW power plant with total investment of US $ 3.5 billion.

NFCL is located at Kakinada on the east coast of India in the state of Andhra Pradesh and is the first natural gas based fertilizer complex in south India and employs state-of-the-art technology. It had the distinction of being the largest single private sector investment in south India at the time of its inception. The plant went into commercial production on August 1, 1992 and is designed to meet high standards of energy conservation and pollutant discharge loads.

The manufacturing facilities comprise a 900 MTPD ammonia plant, a 1500 urea plant, both laid out in single streams and other allied offsite facilities like 2 x 100 MTPH High pressure steam boilers, 2 x 7.5 MW Gas turbines with Heat Recovery Steam Generation (HRSG), Rrw water pretreatment and DM plants, Cooling Towers, Inert Gas Generator, 2 x 5000 MT atmospheric pressure fully refrigerated Ammonia Storage Tanks, Urea Silo, Bagging Plant, Effluent Treatment Plant, etc. The natural gas requirement of about 1.3 million $SM^3$/day is met by Gas Authority of India Limited (GAIL) through a 94 km long pipe line from the Tatipaka gas collection station in the Krishna-Godavari basin. The raw water requirement of about 3.3 million gallons per day is taken from the Samalkot reservoir which is 13 km away from the factory site.

## ENVIRONMENT PROTECTION

The group's mission is to « serve society through industry » and environment protection is an avowed corporate philosophy at NFCL. In pursuit of its mission, the group is guided by its core values: Concern, Commitment, Quality and Integrity. The founder, Mr. K.V.K. Raju believed that « while laws and regulations are promulgated to control pollution, the fulfillment of this objective depends on the sense of social responsibility amongst those engaged in industry. This responsibility extends much beyond the narrow confines of compliance with statutorily stipulated standards. Our aim is, and must be, to maintain ecological harmony that is nature's invaluable, beautiful gift to man ».

In consonance with this, an integrated Environmental Management Plan (EMP) was envisioned at the conceptualization stage of the project and a number of environmental control and monitoring measures have been incorporated in the basic design itself to ensure strict adherence to international standards. An Environmental Impact Assessment (EIA) was made at the pre-project stage based on which the EMP was developed incorporating all the findings of the EIA. Utmost care was taken to maximize the recycle and reuse of various waste waters generated.

### Environmental Impact Assessment (EIA)

NFCL engaged a multidisciplinary agency M/S Richardson & Cruddas to undertake a detailed EIA study. The scope of the EIA covered the following:

- Detailed characterization of the pre-project environment status in an area of 10 km radius from the proposed fertilizer plant site for major environmental components i.e., air, noise, water, land, biological and socio economic environments.
- Identification and quantification of significance of impacts of various operations on environmental components.
- Recommendation of pollution control measures for solid, liquid and gaseous discharges.
- Preparation of EMP detailing control strategies.
- Outlining of post project environmental quality monitoring programme to be pursued.

To identify and quantify the significance and impact of various operations on environment, studies were undertaken to generate base line data on micrometeorology, air quality, noise levels, water quality, flora and fauna, land use and soil quality, socio-economic and health status of the community. Data was collected for a period of one year. Impact on the air quality was predicted by constructing dispersion models for sulfur dioxide ($SO_2$), $NO_x$, ammonia and particulate emissions.

### Adoption of technology

Adoption of cleaner and more efficient technological processes geared towards greater energy efficiency and production efficiency help in preventing pollution at source. Initially the project was based on the usage of naphtha as feedstock for ammonia production and LSHS (Low Sulphur Heavy Stock) as fuel to the boilers and the entire power generation was based on steam turbogenerators. All the EIA studies and clearances from government agencies and stipulations laid by APPCB were based on the usage of naphtha and LSHS. However, with the finding of natural gas in 1988 in the Krishna-Godavari basin, the company took a decision to switch to natural gas from naphtha and LSHS in order to reduce sulphur emissions. This was done although the plant was designed for use of Naphtha and LSHS. NG from KG basin practically contains no sulphur and new $SO_2$ levels came down from 4.2 tonnes/day to traces. But there were no changes made in the pollution control measures adopted earlier such as the chimney height of 120 meters for the steam generation plant and 40 meters for the primary reformer in the ammonia plant. The best available technology at the time of design was selected and care was taken to incorporate all the latest technological features available at that time. The following features were incorporated for the first time in India:

### Ammonia plant

- 25/35 Cr.Ni.Nb. (Manaurite 36 X Equivalent) alloy for the primary reformer tubes at the grass root level.
- Low heat Giammarco - Vetrocoke (GV) process with dual activator for $CO_2$ removal.
- Low pressure synthesis loop of 140 kg/cm$^2$ compared to 220-230 kg/cm$^2$ in the conventional plants with HTAS ammonia technology.
- Provision for surplus LP steam injection into process air compressor turbine.

- Installation of purge gas recovery unit (PGRU) at the grass root level with the ammonia absorber in the PGRU operating at syn loop pressure of 140 kg/cm$^2$.

**Urea plant**

- Installation of ammonia preheater to pre-heat the ammonia entering the urea reactor by utilizing the heat available from LP decomposer vapors.
- Addition of a vacuum pre-concentrator before first vacuum concentrator to concentrate urea solution from 70.1 to 88.5% by utilizing waste heat from MP decomposer off-gases.
- Introduction of carbamate preheater for heating the carbamate solution from MP section before entering the HP carbamate condenser by heat recovery from the high temperature condensate.
- Provision for injection of surplus LP steam generated in the urea plant into $CO_2$ compressor turbine to reduce live HP steam consumption.
- Dry gas seals for $CO_2$ compressor.

**Cooling towers**

- All the cooling tower fans are fitted with dual speed motors to adjust the fan speed.

**Basic philosophy and approach**

Based on the findings of EIA an integrated Environmental Management Plan (EMP) was developed adopting the following approach:

a. Zero discharge of liquid effluent outside the complex
b. Development of a Green Belt and
c. Environmental monitoring.

The basic philosophy adopted during the design stage was that individual plants within the complex treat their effluents within the respective plants and recycle the effluents for process reuse and secondary treatment of combined effluents as a check in the central effluent treatment plant and to further improve the quality of waste water.

**A. POLLUTION CONTROL MEASURES**

The complex embodies the following major pollution control measures:

**1. AMMONIA PLANT**

**a. Liquid effluents**

i. Process condensate which contains $CO_2$, ammonia, methanol, etc. from the front end and $CO_2$ removal section is treated in a process condensate stripper using steam and reused as boiler feed water. Overhead product is recycled to primary reformer. An offspec condensate tank of 1000 m$^3$ capacity has been provided to divert condensate during system upsets and reprocess it later.
ii. Oil contaminated water from pumps and compressors is collected separately and treated to remove oil by a disc oil separator which can remove oil down to less than 10 ppm.
iii. The $CO_2$ removal solvent which contains potassium carbonate, vanadium pentoxide, diethanolamine and glycine drained from pumps, vessels, etc. is collected separately and reused in the process itself and no contaminated water is allowed to go out of ammonia plant.
iv. Very little quantity of aqueous ammonia is formed during reduction due to use of pre-reduced ammonia synthesis catalyst and this is directly lined up to storage and mixed with product ammonia.

**b. Gaseous emissions**

i. Incorporation of a PGRU at the grassroot stage itself to recover ammonia and recycle hydrogen. In case of PGRU trip the gases after ammonia absorption are burnt in the auxiliary boilers in the offsites where the chimney height of 120 meters allows better dispersion of NOx formed if any.
ii. Primary reformer stack has been raised to 40 meters against conventional 30 meters to allow better dispersion of $CO_2$ and NOx of the flue gases.

iii. There is no venting of gases in the ammonia plant even during upset conditions. All the safety valve discharges are connected to two flare stacks (one for ammonia containing gases and the other for non ammonia containing gases) through separate headers.
iv. Use of low NOx emission and high efficiency burners in primary reformer.
v. Use of zinc oxide (ZnO) catalyst instead of activated carbon beds for desulphurisation of natural gas feed.

## 2. UREA PLANT

### a. Liquid effluents

i. Condensate from the urea vacuum concentration section is treated in deep-hydrolyser and distillation column and reused as boiler feed water. An offspec condensate tank of 1000 $m^3$ capacity has been provided to divert condensate during system upsets and reprocess it later.
ii. Drainage facilities to effectively segregate and treat process water, oily water and storm/rain water.

### b. Gaseous emissions

i. Natural draft prilling tower has been designed with a free fall of 75 meter height to limit dust content in the exit air to 40 mg/$Nm^3$. In addition a dedusting system has been provided at the top of the prilling tower to bring down the urea dust emission level to 20 mg/$Nm^3$ by scrubbing the out going air with condensate.
ii. No gas is vented without scrubbing. All relief valves and safety valves releasing vapours have been connected to vent stack extending up to the top of the prill tower.

## 3. OFFSITES

i. Non-chromate cooling water treatment has been adopted. The treatment chemicals are biodegradable and the blow down does not need any special treatment.
ii. The regeneration waters from DM plant and condensate polishing units self neutralize and only small addition of alkali or acid is required to tune the $p^H$ to 7.
iii. Two independent dust extraction systems have been provided in the urea bagging plant where DM water is used to remove urea from the out going air and a dust free atmosphere is maintained. The solution from the dust extraction system is sent to urea plant for urea recovery.
iv. The two ammonia storage tanks (5000 MT each) are double wall double integrity type with suspended deck and provided with:
- dedicated refrigeration system with emergency power connection.
- separate flare stack to burn ammonia in case of excessive pressure.
- water curtain round the ammonia storage tank.
- all safety valve discharges connected to a dedicated flare stack system.

v. The steam and power generation plant has:
- 120 meter height chimney.
- continuous $SO_2$ analyser for flue gases.
- automatic fire protection system in-built for the gas turbine.
- facilities to segregate oily water and boiler blow down for separate treatment.

vi. All flare stacks in the complex have dual firing facility, either NG or LPG with automatic switch over facility in the case of failure of any of the systems and also the flame front generators have dual ignition provision (electrical and mechanical). The flare stacks are 55 M high and are lit continuously with a pilot flame.
vii. Maximized use of dry type of transformers instead of oil filled types. Main receiving transformers have automatic sprinkler system for fire protection.
viii. Meticulous care has been taken in a number of areas to control fugitive leaks and emissions. For example, ball walls have been used instead of gate/globe valves to avoid gland leaks, all steam traps connected to condensation collection system, etc.
ix. All the pits and tanks are lined with impervious lining so as to prevent seepage of any effluent to the ground water system.

## 5. SOLID WASTE

There are no solid wastes are generated except for the spent catalysts which occur in 3 to 5 years and they will be sold to the metal recoverers.

## 6. CENTRALISED EFFLUENT TREATMENT PLANT

This plant takes care of the secondary treatment of the effluents generated in the process plants and works as a back up in case of upset in the pollution control measures of the main plants.

The plant consists of 3 main sections:

1. A thickener and centrifuge system to treat the sludge coming from the raw water pre-treatment plant. Clarified water from the thickener and centrifuge is led to equalization pond.
2. A neutralization pit is provided to receive effluents like boiler blow downs, cooling tower blow downs, neutralized regenerated wastes from DM plant and other contaminated liquids, if any, from process plants. pH is adjusted by adding either acid or alkali and pumped to equalization ponds.
3. Additional disc oil separator has been provided to take care of upset condition of the disc oil separator in main plants. Clarified water is pumped to DM plant.

There are two equalization ponds each of 9600 $M^3$ capacity to hold the effluents. All the treated effluents are pumped to the holding pond of capacity 21000 $M^3$ where fish are bred to monitor level of pollution. The water from the effluent pond is pumped to the Green Belt for irrigation.

**Improvements in operation**

Greater efficiency in production and use of energy contributes to resource conservation and pollution abatement. Thus efforts made towards reducing energy consumption help conserve feedstock and abate pollution. Aware of this fact, NFCL has made various efforts subsequent to commissioning of the complex to improve the capacity utilization and energy usage efficiency. As a result of innovative approach, many operational practices have been changed and process parameters optimized throughout the complex. This has paid very rich dividends as a consequence of which the plant has been consistently operating at a capacity utilization of well over 100% and the overall specific energy consumption of urea in the complex which was at 8.4 MM Kcal/MT just after commissioning leveled out at 5.70 to 5.8 MM Kcal/MT. Also the ammonia consumption per metric tonne urea improved from 0.59 MT to 0.5785 MT. All this has resulted in conserving natural gas and abate pollution.

The extent of recycling and reuse of various condensates is exemplified by the fact that out of the total of 350 $m^3$/Hr of boiler feed water required in the complex the recycled condensate accounts for nearly 300 $m^3$/Hr, only the balance being fresh DM water make-up. The cycles of concentration in the cooling towers has been gradually increased to 6-6.5 from 3-3.5 envisaged at the time of design. Similarly, the output between regenerations of various ion exchange beds has been increased by about 40% in the DM plant and process condensate polishing unit taking advantage of better influent water quality. The benefits of all this on the reduction in waste water generation has been shown under the heading current environmental status.

## B. GREEN BELT

A large Green Belt has been developed in an area of about 700 acres which is nearly twice the area of 380 acres occupied by the plant. The philosophy behind the Green Belt development at NFCL is to improve the ecology and environment of the surroundings of the plant by extensive afforestation. The entire area has been planted with 260,000 plants consisting of 137 species, the selection being based on the broad leafed nature of the trees and its ability to attract birds. Appropriate planting techniques were adopted to overcome adverse soil conditions. Drip irrigation techniques have been adopted in selected areas. There are 11 large water lagoons for Pisci culture which are attracting migratory birds during winter months. An orchard over an area of 50 acres with many varieties of fruits has been developed. Also a deer park has been opened as a precursor to more animal species being inducted.

Thus, the Green Belt is really an ecosystem supporting plant life, aquatic life, bird life and animal life. The entire effluent generated in the complex is utilized in the Green Belt for irrigation. It also serves to attenuate any emission from the factory and segregates the factory complex from Kakinada.

## COMMITTEE OF EXPERTS FOR GREEN BELT

The evolution of this ecological system is the outcome of efforts, combined wisdom and extensive experience of eminent experts in diverse disciplines such as forestry, horticulture, soil chemistry, ornithology, landscaping, animal and aquatic sciences.

The Green Belt at NFCL, Kakinada, had to be established overcoming a lot of difficulties such as those listed below:

**Physiography**

The area consisted of level to gently sloping coastal plains with pockets of low lands, depressions and water logged areas close to the sea coast. Part of the area was under back waters connecting the sea during the high tides.

**Hydrology**

The borrow pits and depressional areas remained water logged almost throughout the year. The deteriorated/salt infested lands also remained water logged for prolonged periods.

**Vegetation**

The area in general was devoid of any vegetation except the sand-casted area which used to have a few « Palmyra » trees. The water logged area towards south-east being highly saline was totally devoid of any vegetation.

**Soils**

The soils support very little vegetation and were primarily covered with sparse grass. The deteriorated soils constituted large contiguous flat lands that had degenerated due to high salt infestation and incrustations on the surface. The sub soils had high concentrations of salts beyond critical limits with electrical conductivity ranging from 10 to 15 µmhos per cm. The available $P_2O_5$ was very low.

It took stupendous efforts by NFCL with the help of experts to overcome all these natural hinderances and to transform a once highly saline marshy area devoid of any vegetation into lush Green park.

**C. ENVIRONMENT MONITORING**

There are three number unmanned ambient air quality monitoring stations in the factory for continuous monitoring of sulfur dioxide, oxides of nitrogen ($NO_x$), ammonia, suspended particulate matter (SPM), carbon monoxide, methane and non-methane hydrocarbons. These are continuously analysed and data recorded in the computer situated in the central laboratory. In addition to the above, two more ambient air monitoring stations are set up at the south and east locations of Kakinada about 5 km away from the plant. Also micrometeorological data namely wind velocity and direction, rainfall, temperature, relative humidity and barometric pressure are recorded continuously.

An analyser continuously monitors $SO_2$ in the chimney in the steam generation plant.

In the liquid effluent pH, ammoniacal nitrogen, total Kjeldhal nitrogen, oil and grease, chloride, phosphates, nitrates, BOD, COD, etc., are regularly monitored and analyzed.

All the information pertaining to pollution control and environment monitoring are regularly sent to Pollution Control Board.

**MANAGEMENT SET-UP**

Environmental and Safety Management set-up is headed by Director (Technical) along with senior members such as General Manager (Works), Assistant General Manager (Technical), Manager (Environment) and Manager (Fire & Safety).

There are two separate wings one for operation & maintenance and the other for regular monitoring.

## CURRENT ENVIRONMENTAL STATUS

### Liquid effluents

| | Envisaged in design based on | | Actuals | | | |
|---|---|---|---|---|---|---|
| | LSHS & Naphtha | Natural Gas | 1992-93 | 93-94 | 94-95 | 95-96 |
| Total complex water requirement $M^3/h$ | 1000 | 850 | 787 | 660 | 635 | 620 |
| Effluent generation $M^3/h$ | 303 | 289 | 152 | 130 | 126 | 125 |
| Raw water consumption $M^3$/MT urea | 16 | 13.63 | 12.6 | 9.00 | 7.31 | 6.95 |
| Waste water generation $M^3$/MT urea (EPA STANDARD = 5 $M^3$/MT urea). | 4.8 | 4.6 | 2.81 | 1.92 | 1.64 | 1.56 |
| Ammonia let out in effluent kg/MT urea | - | 0.780 | 0.774 | 0.063 | 0.046 | 0.03 |

### Liquid effluent quality

| PARAMETER | ACTUAL (TYPICAL) | EPA STANDARD | RAW WATER ANALYSIS (TYPICAL) |
|---|---|---|---|
| Temperature °C | 28 - 32 | Shall not exceed 5°C above receiving water temperature | |
| pH | 8.1 | 5.5 - 9.0 | 8.1 |
| Dissolved solids | 1144 | 2100 | 11 |
| Ammoniacal nitrogen (as N) | 21 | 50 | - |
| Nitrates (as N) | 3.6 | 10 | 0.5 |
| Total Kjeldahl Nitrogen (as $NH_3$) | 35.7 | 100 | - |
| BOD | 20.1 | 30 | 1.6 |
| COD | 33.6 | 250 | 15 |
| Oil & grease | 3.1 | 10 | NIL |
| Phosphates (as P) | 2.9 | 5 | - |
| Chlorides (as Cl) | 418 | 1000 | 21 |

All parameters except temperature and pH are in mg/l.

### Gaseous emissions

| | Design mg/Nm³ | Actual | | EPA STANDARD | |
|---|---|---|---|---|---|
| | | mg/Nm³ | Kg/Te | mg/Nm³ | Kg/Te |
| Urea dust in prilltower exhaust air | 30 | 20 | 0.21 | 50 | 0.5 |

### Ambient air quality

The analysis of air quality data for the three ambient air quality monitoring stations provides the following scenario in respect of various atmospheric pollutants.

| POLLUTANT | 1995-96 CONCENTRATION MICROGMS/M³ | NORM MICROGMS/M³ |
|---|---|---|
| i. Sulfur dioxide ($SO_2$) | 0.2 - 8.7 | 80 |
| ii. Oxides of nitrogen ($NO_x$) | 1.3 - 17.4 | 80 |
| iii. Ammonia ($NH_3$) | 2.3 - 28.0 | No norm yet |
| iv. Suspended particulate matter (SPM) | 20.8 - 280.3 | 200 |
| v. Carbon monoxide | 0.0 - 1000 | 2000 |

**Soil quality improvement**

As mentioned earlier the entire treated effluent is used for irrigation in the Green Belt. The pH of soils irrigated with treated effluent has come down to 7.54 from 8.69 found in the plain water irrigated soil. Also the electrical conductivity has dropped down to the normal level of around 1 micromhos/cm in all effluent irrigated soils. In addition the organic carbon which is an index of available nitrogen has increased from 0.01% to 0.53% indicating that soil fertility has considerably improved due to the application of treated effluent for the Green Belt development.

| SOIL QUALITY PARAMETER | BEFORE GREEN BELT DEVELOPMENT | PRESENT |
|---|---|---|
| pH | 8.69 | 7.5 |
| Conductivity micromhos/cm | 8.0 | 1.0 |
| Organic carbon % wt. | 0.01 | 0.53 |

**Noise control**

The plants have been designed and built so that noise levels are well below OSHA standards of 90 dBa for 8 hours operation.

Presently the noise levels recorded at different locations within the plant range from 59 to 90 dBa. Noise level of pre and post status at outside plant side are more or less the same with insignificant reduction/increase at all the stations.

It was experienced that during plant upsets the release of front end gases into the flare header in the ammonia plant was causing high noise levels of around 106 dBa. Acoustic insulation has been applied to the flare headers and noise levels brought down to below 100 dBa.

**SAFETY SYSTEMS AND PRACTICES**

The emphasis is on sound safety management systems and practices. NFCL has established a full fledged and round the clock manned Fire & Safety Section.

**Safety policy**

The safety and health of all employees is of paramount concern in the company. The management is fully committed to maintain the highest standards of safety and health in the work place.

It is the firm resolve of the company that every effort would be made to promote safety consciousness and safe behaviour among all its employees and to make safety an integral part of each and every procedure in the company.

**Process safety features**

Process safety forms chief area of attention. Entire complex has been built to international standards and codes following sound engineering practices. In built safety systems have been incorporated in the design

stage itself like independent solid-state electronic safe shut down system delinked from process control system with mosaic display for operator interaction, extensive interlocks, alarms and trips, provision of uninterrupted power supply for critical equipment, diesel generators for emergency power, etc.

NFCL was the first fertilizer plant in India to use Distributed Control Systems (DCS) in both ammonia and urea plants at grass root level. Associated with this are redundant multi loop controllers having CRT operator interfaces. Events logging, alarm logging and shift log reports are computerised. For critical control loops like compressor anti-surge controllers, micro-processor based single loop controllers with a DCS communication link are employed. All the field mounted devices were selected so as to meet the hazardous zone requirement through intensically safe circuits and explosion-proof enclosures, wherever required. The 2 out of 3 voting system is employed for critical interlocks for increased safety and reliability of the plant operations.

An underground hydrant system has been laid as per Tariff Advisory Committee (TAC) norms with reserve fire water capacity. Smoke detectors and fire alarm points are provided at a number of places in the plant area.

**Safety audits**

Regular safety audits both inhouse and by external agencies of repute are undertaken to evaluate the effectiveness as well as improve the existing systems.

Inhouse audits cover various areas like work permits, piping color code & identification, adequacy and compliance, ladders and stair cases, fire fighting equipment, non-return valves (NRV), etc. In addition, frequent works spot inspections in process plants and offsites units are done.

Every year an audit of the entire complex by an external safety consultant of repute is organised. The recommendations of the audits are reviewed and implemented as expeditiously as possible. M/S KLG-TNO Safety Technology Pvt. Ltd. conducted a Quantitative Risk Assessment for the entire complex in 1994 and M/S Chemical Design Company carried out a safety audit in February 1996.

**Hazard identification and disaster control**

Hazard identification and analysis studies are undertaken periodically either inhouse or with the help of external experts. For example, a HAZOP study was conducted an year ago for the atmospheric ammonia storage system in the complex by an external consultant of repute and the practicable suggestions implemented.

The Company has prepared an onsite Disaster Management Plan which was taken on record by the State authorities. Two major mock drills are conducted every year to test its effectiveness and for updation. In addition, mini mock drills are also conducted once in every two months in designated areas to impart more intensive training to the personnel.

**Work permit systems and safe operating procedures**

A safety manual has been brought out and distributed at all strategic locations in the factory. The manual covers various aspects like safety permit systems, safe work instructions, material safety data sheets, etc. for all the chemicals like ammonia, chlorine, sulphuric acid, hydrochloric acid, sodium hydroxide, urea, various catalysts, proprietory items and other chemicals. In addition, the manual describes safety precautions and guidelines for handling a number of substances like natural gas, carbon dioxide, hydrogen, nitrogen, hot condensates, LSHS, diesel oil, ammonium carbamate, etc. and to carry out jobs like welding and cutting, safety in chemical laboratory, working at heights, compressed gas cylinders, etc. A handy and concise safety pocket manual which can be carried in pocket at work has been distributed to all employees.

No maintenance or repair work is undertaken without a work permit. Work permits are classified according to the criticality of work nature and issuing authorities specified. For example, the issuing authority for restricted vessel entry is only Asst General Manager (Production) and above.

**Process/plant modification procedure**

A Plant Modification Authorisation (PMA) system is in vogue and no unauthorised modification or change of operating procedure is permitted without prior approval. Any proposed modification or change in procedure

is first reviewed and approved by all the Section Heads concerned. HAZOP study is also carried out necessarily prior to getting the final approval by the top management. Only then the changes are implemented.

**Accident reporting and investigation**

All accidents and unusual occurances are investigated and steps recommended to prevent recurrence of events in future. Special committees are constituted in case of major incidents.

Records of accident statistics classified and stratified into various categories are circulated among all those concerned.

**Personal protective equipment**

The Fire & Safety Section ensures the availability of different kinds of personal protective equipment like chemical resistant suits, fall arrestors, ear muffs, face masks, goggles, nose masks at all workspots in addition to the conventional protective gear. Regular inspections are carried out so that the equipment are always in working condition.

**Compliance with statutory regulations**

Full compliance with various statutory regulations like explosive rules, petroleum regulations, gas cylinders, static and mobile pressure vessels, Indian electricity rules, Indian boiler regulations, factories act, etc. is met.

**Employee involvement and participation**

The company recognises the fact that first line supervisors are the key link in making safety happen. Line management rather than safety department or governmental agencies are looked up for safety performance. Safety performance also forms one of the criteria of evaluation during the supervisors annual performance appraisals. Employee involvement and participation in safety issues is ensured through departmental safety sub-committees and Central Safety Committee, the main objectives of which are to bring about safety awareness among the employees, review the steps to be taken to ensure accident free environment, review of safety management of the complex, suggest schemes for overall improvement of safety in the factory and improve coordination among various departments in matters relating to safety. Matters of policy or conflicting priority are resolved by Central Safety Committee which is the apex committee.

**Education and training**

Periodic training and retraining courses on a wide variety of safety and related topics are organised throughout the year at all levels. The training needs for the employees are identified by the sectional/departmental heads and are communicated to the Manager (Fire & Safety) who in turn coordinates with Training department and organises the required training courses with the help of external and/or internal faculty as necessary.

New entrants are indoctrinated in safety, use of personal protective equipment and basic fire fighting before being finally placed in the sections recruited for.

**Communication and promotion**

A inhouse safety magazine « SURAKSHA » is distributed every quarter to all employees. In addition, a one page weekly bulletin covering a specific safety or health topic is distributed to all. Also select articles on safety from various publications are distributed to personnel concerned.

Good house keeping inspections and competitions are held among various plant units to maintain high standards of house keeping. Smoking is prohibited in the plant areas.

Every year the Company observes National Safety Day, Road Safety Week, Fire Day, etc. to bring about awareness and attitudinal changes amongst the employees.

In its three years and a half of existence in operation, the company has achieved one million reportable-accident free man hours once and two million reportable-accident free man hours once.

**Health and hygiene administration**

All the employees undergo annual medical check-ups and the health history record of each employee is maintained by the Medical Officer. Each employee is given his/her Medical file which contains the X ray, ECG & Lab investigation reports of each year. Not only the employees but also the families of the employees are extended the facility of health check-up.

The company maintains a well equipped dispensary with a full time doctor and round the clock medical assistants. The dispensary has inhouse facilities like X Ray, computerised spirometry, computerised audiometry, auto blood analyser, electro cardiograph, and other clinical laboratory facilities. In addition, it is also equipped with emergency treatment facilities such as artificial respirator, oxygen masks, anti-snake venom, etc. A fully equipped ambulance is available round the clock to meet any emergency. All the employees as well as dependant parents, spouses and children are provided the facility of annual medical examination and detailed reports thereof are given to each in the form of medical file. The summary of the data is maintained in the computer data bank. These data pertaining to the employee is compared with the pre-employment check-up data which forms the base so as to protect the employee against occupational hazards and also other ailments. The employee and his family are also advised by the doctor the course of treatment as well as prevention aspects. The company also has a franchise with a well equipped local hospital for treatment of employment injuries, if any. The company has schemes for reimbursement of medical expenses in respect of self, dependant parents upto 75 years of age, spouse and family.

First aid training programmes are organised for the employees and inhouse safety magazine also carries health bulletins for the benefit of employee and family. The company has a well furnished club with health and recreation facilities such as gym, swimming pool, and other indoor and outdoor games. The membership is open to employees at all levels and their families so as to enable them avail these facilities and maintain physical fitness.

A Sports Committee encourages inter-department as well as inter-company teams for participation in various sports and athletics. Special training in occupational health and industrial hygiene is provided to select employees. Occasional summer camps are organised in swimming, yoga, stress management, martial arts, etc. in addition to health camps. Health education is also imparted to children in the school run by Nagarjuna Educational Trust.

The hygiene in the canteen is looked after and ensured by the personnel and administration department of the company.

The work environment at various locations in the factory is regularly monitored for ammonia concentration, noise levels, etc. Ammonia and chlorine leak detectors are installed at strategic locations which set off alarms at present values. The employees are provided with ear muffs in areas like compressor houses where there is a possibility of the sound levels being high.