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RE-ENGINEERING OF SAFETY SYSTEM IN A LARGE FERTILIZER COMPLEX

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RESUME

Gujara Narmada Valley Fertilizers Co. Ltd. (GNFC) possède un grand complexe d'engrais comportant un groupe d'unités d'ammoniac, urée et nitrophosphate. Récemment, la société a décidé de revoir la conception du système de sécurité pour en améliorer la performance. L'étude de toutes les unités par HAZOP a été conduite en collaboration avec Risk Assessment & Safety Audit. Compte tenu des progrès récents, tous les aspects du système de sécurité ont été examinés. Un plan d'action détaillé a été élaboré et peut être mis en oeuvre. La communication souligne les différents aspects de ce programme de réhabilitation du système de sécurité.

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I. INTRODUCTION AND COMPANY PROFILE

Gujarat Narmada Valley Fertilizers Co. Ltd. (GNFC) was jointly promoted by the Govt. of Gujarat and the Gujarat State Fertilizers Co. in 1976. The fertilizer complex initially consisted of 1350 MTPD ammonia plant, based on partial oxidation of fuel oil and a 1800 MTPD urea plant based on ammonia stripping process. The location of the plant is about 5 km from the Holy Narmada River and in the industrially backward district of Bharuch, Gujarat State. The Ammonia-urea plants were commissioned in December-1981 and commercial production started from July-1982. In about a decade, as a part of corporate planning for diversification, the Company put up the nitrophosphate complex with production capacity of 475 MTPD of ammonium nitrophosphate and 475 MTPD of calcium ammonium nitrate alongwith 630 MTPD of weak nitric acid and 100 MTPD of concentrated nitric acid. Apart from these, the Company had also put up plants for manufacturing methanol, formic acid and acetic acid. All the plants are operating well above 100% capacity utilization. The details of Company profile and various plants' capacities are as per enclosed Annexure-A.

II. FACTORS INFLUENCING RE-ENGINEERING PROGRAMME

Although the safety records of the Company had been quite satisfactory, there was a slow increase in the number of accidents, both minor and major since 1990. The statistical data about frequency rate and severity rate as well as minor and major accidents is as per attached Annexure-B. Also, there have been three cases of fire in the electrical sub-station resulting in substantial production loss and the attendant problems of fire fighting the electrical fire. Apart from this, there were incidents of explosion in the oxygen vent line of the gassifier, fire and explosion in captive methanol storage tank and few incidents of the ammonia/carbamate leakages in urea plant.

The other major point which influenced the re-engineering of safety system was that we had gone in for a massive plan of expansion and diversification as elaborated earlier. This involved a complex networking and integration between plants and majority of them were with the main plant i.e. ammonia plant. There are still some projects which are under pipeline and will definitely call for further integration which will increase the complexity.

Another major consideration was that since the safety record was good, the employees and to some extent even middle management level had developed some complacency towards safety aspects. The top management observed that even with some incentives for safety improvement, the enthusiasm of employees towards safety was on decline. The employees tend to believe that safety is the responsibility mainly of Fire and Safety Department. We also reviewed the existing Safety Department set up (attached at Annexure-C) and found that looking to the task ahead, this appeared to be inadequate.

Since our various plants handle toxic and flammable chemicals, such as ammonia, carbamate, hydrogen, CO, CNA, chlorine, methanol, naphtha, etc. and the memory of major disaster like Bhopal tragedy is still hovering on our memory, GNFC management decided to go for re-engineering of safety system.

III. RE-ENGINEERING PROGRAMME

Having felt the need to overhaul the safety system, we tried a kind of network approach to draw out the re-engineering programme. The various strategies adopted to make re-engineering programme effective are given below:

1. Formation of task force (Please see attached Annexure-D).
2. Conducting Hazard Identification round for each plant (Please see attached Annexure-E for check list on hazard identification).
3. To train our engineers on HAZOPs techniques and also to carry out consequence analysis and risk assessment studies.
4. Re-structuring of safety department by inducting engineers and operators who had working knowledge of operating the plants.
5. To draw out an On-site and Off-site emergency plan.
6. Various awareness programmes.

We briefly mention hereunder the various strategies:

FORMATION OF TASK FORCE:

The general belief about safety is that it is the responsibility and main function of Safety Department. We realized that safety is a function of everybody right from top to the bottom level and to be a successful programme, the top management commitment is a must. Based on the four 'E' concept i.e. Engineering, Education, Encouragement and Enforcement. We decided to form a task force from various discipline i.e. from Production, Mechanical Maintenance, Instrumentation, Electrical, Safety, Technical Services, Design Engineering. The task force was made aware of above four 'E' concept, which is briefly described as given below:

The pre-requisite for any process plant to perform very well either from productivity angle or safety angle is sound engineering. GNFC management selected best technology available at that time for all their plants and it was ensured that detailed engineering was done with all the necessary safety precautions and engineering codes. It was ensured that right at the design and engineering stage, various safety protections such as no. of safety valves, pressure control valves, rating of equipment and pipings for worst condition, running machineries protection systems, etc. were adequately taken care by the designers. Also during the construction and erection stage with the close supervision by the GNFC Officers and Staff members, it was ensured that proper welding techniques were used and various welding procedures and inspection procedures were followed.

Of course, only a good engineering is not enough as far as safety is concerned. Once the plants were in pre-commissioning and commissioning stage, continuous and conscious efforts by all concerned only could result into good safety records. All employees working in the plant area should be subjected to compulsory safety training programmes which included practical training as well. This process is a continuous one and these training courses are periodically repeated for employees. The safety hand-book which covers some practices, procedures of safety and properties of hazardous and toxic materials have been issued to all the employees. Apart from training programmes, seminars and workshops on safety are regularly conducted wherein the employees get benefit of expertise knowledge of outside agencies such as Loss Prevention Association, FAI, NPC, etc.

Motivational aspect cannot be neglected in any safety programme or system. At GNFC, safety quiz is a regular feature. Inter departmental competition, essay writing and its presentation are periodically held and the winners are suitably rewarded which gives encouragement for others as well.

All the above efforts are sometimes not sufficient and enforcement is required. At GNFC, we have made it compulsory to wear safety helmets in the plant area and also for the scooter riders. Wearing of safety shoes, safety belts for working at high elevation, etc. are vigorously followed. A walk around management concept is introduced and employees not following the safety procedures and practices are informed about their unsafe habits, acts and are asked to correct the same.

HAZARD IDENTIFICATION PROCESS:

The next strategy was to start Hazard identification of all the plants. The group adopted the following modus operendi:

(a) List of possible risks revealed by initial information source.

(b) Investigate each by:

- Study
- Inquiry
- Review of the documents
- Physical Inspection

(c) List and define each Hazard existing or can exist and thereafter give suitable recommendations.

To ensure that all the safety aspects are covered, a check list was prepared and all the plants are subjected to the Hazard Identification Process accordingly. The contents of the check list are as per Annexure-E.

HAZOPS AND CONSEQUENCE ANALYSIS:

The next step in re-engineering programme was to appoint a very reputed Consultant M/s. Engineers India Limited (EIL) in October-94 and they were entrusted with following specialized jobs:

- **HAZOPs study:**

  M/s. EIL's representative trained our 16 engineers of different discipline to carry out HAZOP studies on P & I Diagrams. After getting 10 days training, our engineers carried out HAZOP study of all the plants with a particular emphasize on the various integration between the plants. A system of presentation was introduced for each team of four engineers wherein the various recommendations were presented in front of Managers, Sr. Managers and Chief Managers for their review. Finally all the four teams discussed the recommendations, threadbare with the Consultant and HAZOP reports were prepared for each Plant. Our Consultant also carried out safety audit for one week.

- **Consequence Analysis:**

  They were also entrusted with the specialized job of carrying out the consequences analysis taking into consideration various failure events and failure frequency. Their advise was also sought for improving our disaster management programme.

Based on above study by our Consultant and HAZOP study by our own engineers, we prepared an Action Plan which has been circulated to all the middle and top management groups. The major recommendation of this action plan are as per attached Annexure-F.

REVISED ON-SITE & OFF-SITE EMERGENCY PLANS:

Earlier, we had prepared an on site and off site emergency plans. These plans were discussed with our Consultant and revised plan has been made considering various aspects of consequences analysis and safety audits carried out earlier. The level of responsibilities both for on site and off site emergency plans have been identified clearly. One Hazard control programme, which is as per attached Annexure-G is also being followed. Also the emergency control centre which was proposed earlier near Urea Plant will be shifted to a new location near the training centre, which is not in the wind direction and also at safer distance.

VARIOUS AWARENESS PROGRAMME:

Large scale Mock Drills, involving the neighbouring localities, cannot be conducted due to the fact that these are likely to create fear psychosis and insecurity among the neighbouring population which can lead to unfavourable situations. To obviate this disadvantage, it has been proposed that suitable demonstration and awareness programmes to be arranged. These programmes should be suitably designed, keeping in view of the population mix, e.g. programmes should be very simple for uneducated mass, while for doctors the programme should be very elaborate, giving them the complete properties of hazardous materials being handled by the unit so that they can determine correct type of medicines and treatment. At GNFC, we have already started these programmes.

The awareness among top management is generally good, but it should percolate down the line to the operating level. A drive for safety improvement will be launched shortly.

IV. CONCLUSION

Re-engineering basically involves fresh outlook and thinking and a true introspection of the existing system. At GNFC, we have made an attempt to carry out this process of re-engineering in our Safety system as outlined above. An action plan has already been drawn up and some of the actions have already been taken. We expect to complete the action plan in about a year. To reduce the number of accidents, to eliminate the possibilities of any major disaster and to improve our preparedness level in case of an eventuality of any major disaster, this programme will be very useful.

Apart from the direct benefits, we have started feeling indirect spin-off effects like improved documentation, updation of operating and maintenance manual, P & I diagram, etc. and improved awareness amongst our employees towards safety. We have also incorporated HAZOPs procedure for all the new modifications, before according technical approval to the modifications. With the use of latest Information Technology such as Pagers, Computers, etc. and after effective implementation of HAZARD CONTROL PROGRAMME, we intend to further improve our safety system.

Ultimately, we are aiming towards rather a very difficult goal of achieving « **ZERO ACCIDENT AT GNFC** ».

ANNEXURE A

CORPORATE PROFILE

1.	Name of the industry	: M/s. Gujarat Narmada Valley Fertilizers Co. Ltd.
2.	Address	: P.O.: Narmadanagar Phone: (02642) 47001 to 47005 Dist.: Bharuch, Gujarat State Fax : (02642) 31595
3.	Location	: On the river Narmada, Bharuch, District of Gujarat State
4.	Type of organization	: Joint Sector Company
5.	Year of establishment	: Registered on 10th May, 1976
6.	Capital and finance structure	: Total capital investment is Rs.1006.87 Crores = Rs 10,068.7 million
7.	Ammonia-urea plant on structure	: December, 1981
	Commercial production	: July, 1982
	Ammonia plant capacity	: 445,500 TPA (World's largest single stream fuel oil based)
	Urea plant capacity	: 594,000 TPA (World's largest single stream)
	Methanol plant capacity First Phase - 20,000 TPA Second Phase - 100,000 TPA	: 120,000 TPA
	DSS plant capacity	: 20,000 Lines PA
	PCB plant capacity	: 44,000 Sq.Mtrs. PA
	Captive power plant capacity	: 50 MW
	Formic acid plant capacity	: 5,000 TPA (Country's Largest)
	Concentrated nitric acid	: 33,000 TPA (Country's Largest)
	Weak nitric acid	: 207,900 TPA
	Ammonium nitrophosphate	: 142,000 TPA
	Calcium ammonium nitrate	: 142,000 TPA
	Acetic acid plant	: 50,000 TPA

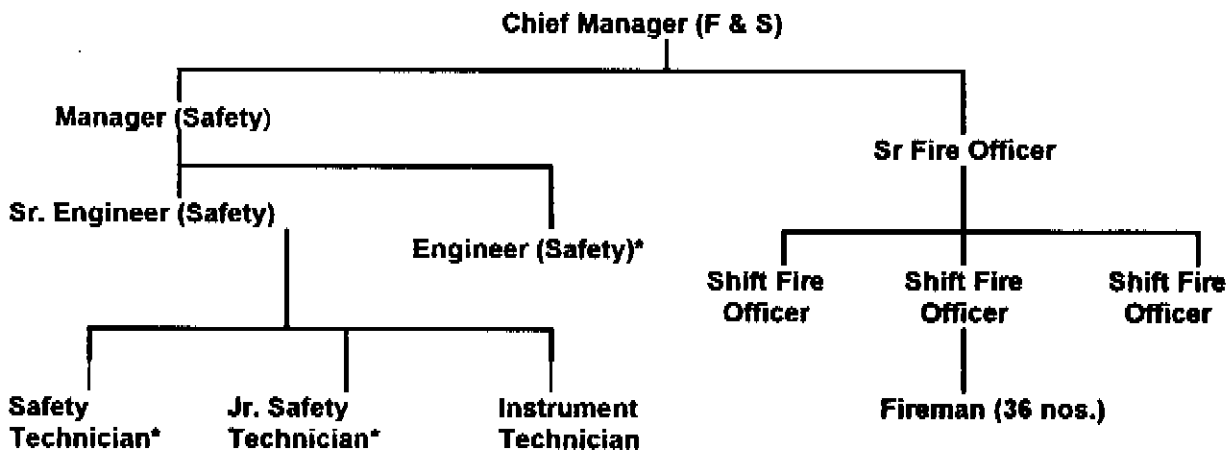
ANNEXURE B

Year	Million man-hour worked	No. of major accidents	No. of minor accidents	Frequency rate (FR)	Severity rate (SR)	FR X SR 1000 injury index
1981	6.949	26	13	3.74	2006	7.5
1982	4.412	34	18	7.62	83	0.63
1983	5.0	37	10	7.4	138	1.02
1984	6.20	41	13	6.60	82.9	0.55
1985	8.56	10	27	1.17	45.20	0.05
1986	9.12	20	28	2.19	1346	2.94
1987	9.16	11	35	1.20	625	0.75
1988	9.5	24	35	2.52	1150	2.9
1989	8.64	13	26	1.50	34.83	0.052
1990	8.5	31	37	3.64	2113	7.69
1991	9.092	21	44	2.30	59.72	0.137
1992	9.58	41	34	4.28	655.40	2.805
1993	9.58	4	84	0.4175	639.24	0.2668
1994	9.58	3	59	0.31	13.98	0.0043
1995	10.23	8	64	0.782	1186.77	0.926

1. FR = Frequency rate = $\frac{\text{N° of major accidents}}{\text{Million man hr worked}}$
2. SR = Severity rate = $\frac{\text{N° of man-day lost}}{\text{Million man hr worked}}$
3. 1 fatal accident = 6000 man-days lost

ANNEXURE C

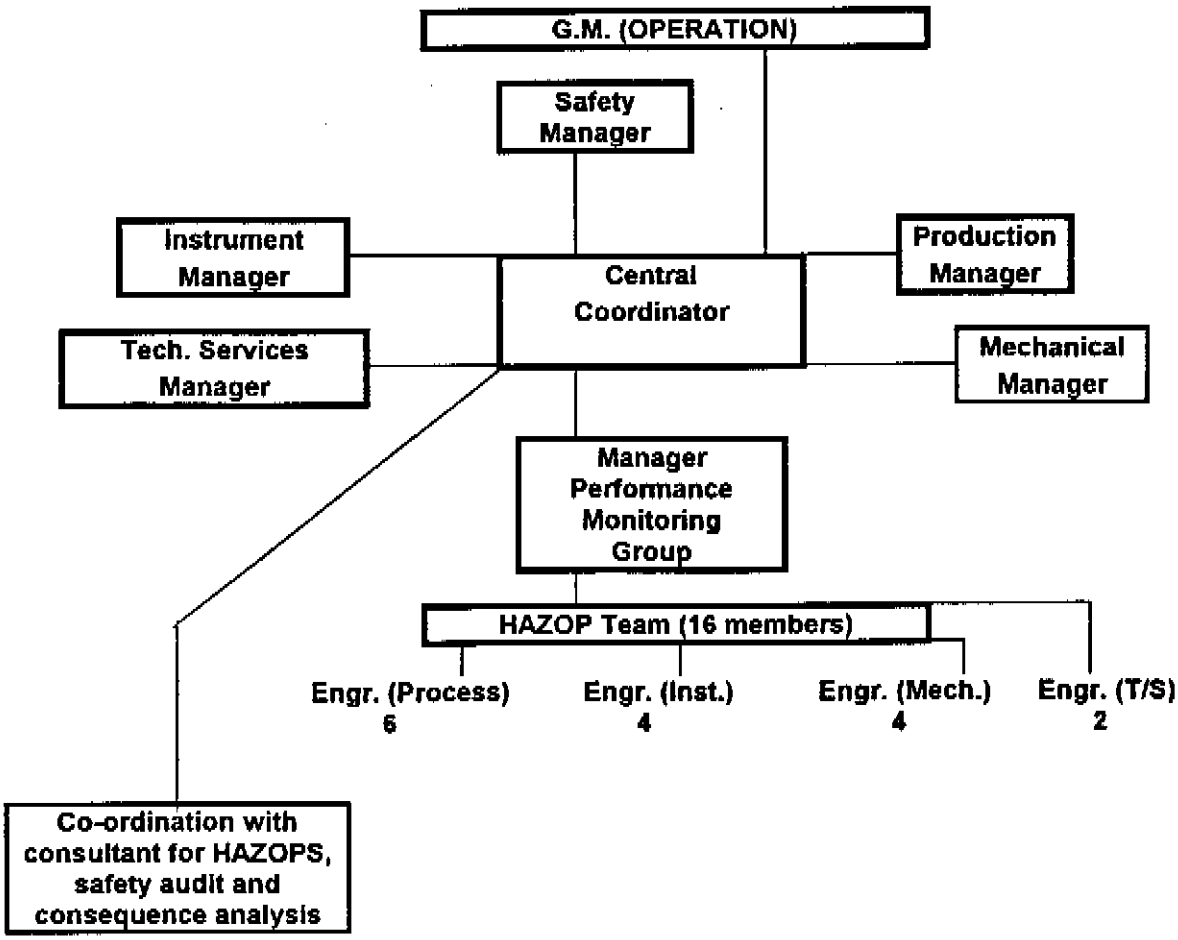
REVISED FIRE AND SAFETY SET-UP



**Employees drawn from plant and added later-on in F & S Dept.*

ANNEXURE D

TASK FORCE FOR RE-ENGINEERING OF SAFETY SYSTEM



ANNEXURE E

CHECK LIST FOR HAZARD IDENTIFICATION

1. Safety valve status and isolation system.
2. Status of PCVs.
3. Leakages in the plant.
4. Earthing of equipments / buildings.
5. Oil level in MOCBs and transformers.
6. Safety provisions in sub-station.
7. Permit system and electrical isolation system.
8. Sealing of junction boxes (instrument and electrical) and terminals in hazardous area.
9. Status of cable trenches and cable racks (instrument and electrical).
10. Sealing of electrical instrument in hazardous area.
11. Cooling tower spray arrangement during shut down period.
12. Gasifier and superheater hotspot checking.
13. Shut down checkings of protections and simulations tests.
14. Routine tests:

    a. Overspeed checking of turbines including expansion turbine
    b. Chain blocks and lifting tackles testing
    c. Thickness measurement

    Hazardous area:

    d. Checking of fire alarm system
    e. Tank farm area - sprinkler, foam system - periodical check
    f. Fire monitoring status

15. Corrosion survey of structures and cable trays.
16. Fire proofing status.
17. Safety devices of the lift and related aspects.
18. Identification status.
19. Identification of area w.r.t. hazardous involved.
20. Acid tank status.
21. Acid tank refractories.
22. House keeping.
23. Present deficiency.
24. Purging system.
25. Factory law requirement

ANNEXURE F

MAJOR RECOMMENDATIONS OF RISK ANALYSIS

SR.NO.	RECOMMENDATION
1.	To install appropriately designed permanent structures of water curtains to dilute vapour near the units handling ammonia like Ammonia unit, Urea unit, ANP Unit, Ammonia Boil off compressor area, etc. which should be operable from local and remote in case of emergency.
2.	To provide adequate gas detectors (carbon monoxide, hydrocarbon, ammonia) at vulnerable points. These will give alarm in advance, in case of leakage.
3.	For containment of small leakages in ammonia refrigerated storage area, a kerb wall / fire wall of 600 mm is to be constructed between the single integrity and the double integrity tanks to restrict the spread of liquid ammonia.
4.	To restrict boil-off rate of liquid ammonia released from storage tank which forms pool, paving the entire dyke floor with properly reinforced concrete is also recommended.
5.	Emergency control centre is to be provided at a safe place in the complex for taking action from this place during emergency. GNFC training centre is recommended and a second choice can be the bagging plant. All facilities to be provided in ECC.
	Major Recommendations of Safety Audit.
6.	A formal procedure for approving the modifications which include HAZOPs should be evolved. No modifications should be carried out unless otherwise scrutinised from safety point of view and approved by competent authority.
7.	Through investigation about the adequacy and suitability of process safety devices, e.g., pressure safety valves, emergency vent valves and shut down valves, etc. keeping in mind the enhanced unit throughput.
8.	To keep record of « near misses » and analyse the cause of accidents including injury to the personnel which will help in preparing suitable action plan(s) to avoid such occurrence in future.
9.	Safety guidelines such as working at height, area / tank cleaning, hydroblasting, hot and cold bolting, pneumatic testing, dismantling and demolition, etc. would be helpful in reducing chances of accidents in such jobs.
10.	Area classification and selection of equipment for process cooling tower needs to be updated in line with latest API recommendations.

ANNEXURE G

INTEGRATED HAZARD CONTROL PROGRAMME:

Following figure gives the detail understanding of integration of accident prevention into all our jobs / activities.