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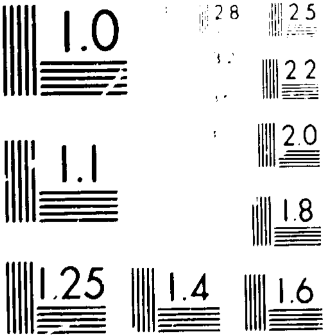
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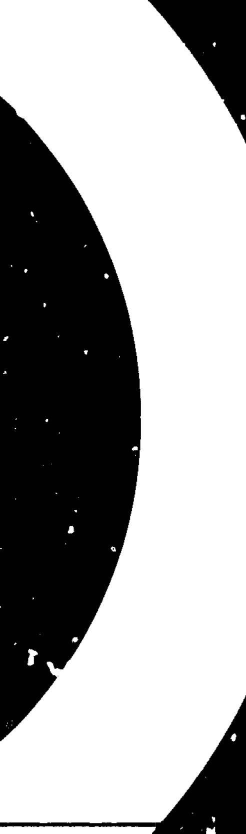
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

SAFETY IN THE PRODUCTION, TRANSPORTATION AND STORAGE OF FERTILIZERS

Report of an Interregional Meeting
sponsored jointly by the
United Nations Industrial Development Organization,
the Fertilizer Association of India,
the Association des Producteurs Européens d'Azote
and the
International Superphosphate Manufacturers' Association

New Delhi, 8 – 10 December 1980



CONTENTS

Explanatory notes

References to "tons" are to metric tons.

Besides the common abbreviations, symbols and terms, the following have been used in this report:

AN	ammonium nitrate
DM	demineralized (water)
MAP	monoammonium phosphate
NPK	nitrogen, phosphate, potash
UAN	urea ammonium nitrate

The following abbreviations of organizations are used in this report:

APEA	Association des Producteurs Européens d'Azote
FAI	Fertilizer Association of India
ISMA	International Superphosphate Manufacturers' Association
MCA	Manufacturers Chemists Association

INTRODUCTION

The Interregional Meeting on Safety in Production, Transportation and Storage of Fertilizers, organized by the United Nations Industrial Development Organization in co-operation with FAI, APEA and ISMA, was held at New Delhi, India, from 8 to 10 December 1980.

The rapid technological developments in the fertilizer industry, e.g. the large single train plants, high concentrated AN-fertilizers and bulk transport and handling, require not only higher safety standards but also, in some cases, a new approach. For instance the hazards inherent in large-scale manufacturing of fertilizers have prompted questions regarding the environment and public safety.

The aim of the Meeting was to improve general safety standards and to give information on new developments in the field. Papers were submitted by the organizing bodies and developing countries.

The Meeting had the following objectives:

(a) Exchange of information on safety aspects of production, storage, transport and handling of fertilizers;

(b) Improvement of safety standards;

(c) Decreasing or eliminating occupational health hazards to employees;

(d) Improvement of public safety and the safety of the environment.

I. CONCLUSIONS AND RECOMMENDATIONS

Session I: Design considerations

1. Excess of plant instrumentation can cause operating problems that may lead to plant shut-down. Therefore, instrument systems in fertilizer plants should be designed to an optimum requirement level.

2. Instrument design consultants have usually little experience with the operating problems of a fertilizer plant. Generally also the feedback information from the operating plant is very limited. The basis for an optimal instrumentation design is that the management of the company clearly specifies its policy in respect of operating and maintenance aspects. Further, instrumentation design consultants, as well as operating and maintenance personnel, should be involved at a very early stage of the plant design.

3. The CO_2 feed originating from ammonia plants for urea plants usually contains a very small amount of hydrogen. The accumulation of this hydrogen in certain parts of the urea plant represents a potential risk of explosion. CO_2 feed for urea plants should be free of hydrogen.

Session II: Operational and maintenance considerations

1. Corrosion is experienced as one of the main problems in phosphoric (wet) acid plants. The frequent failures generally result from the poor quality of the materials of construction, for instance, in the improper way the rubber lining is applied, and careless maintenance. The choice of the materials of construction should be based on an analysis of the impurities present in the acid such as Ca^{++}, F^-, Cl^- and SO_4^{--} ions. Attention should be paid to the way lining is applied.

2. Predictive maintenance is a valuable tool in reducing the possible failures of equipment. Moreover, it enables a better scheduled maintenance. With the aid of the highly advanced testing equipment currently available predictive maintenance should be organized in every plant. It is recommended that a special inspection department should be set up for this purpose.

3. Asbestos is very damaging to the lungs. It should be banned from all plants and should be replaced by the substitutes now available on the market. Personnel that have to work with existing asbestos constructions must be protected by special dust masks.

Session III: Safety in ammonia plants and related facilities

1. Stress corrosion cracking is still a problem of pressurized storages. Parts per million (ppm) of oxygen in the liquid ammonia is regarded as the cause of this type of corrosion. The addition of 0.2% DM water was shown not to eliminate all the stress corrosion cracking. Pressurized storages of liquid ammonia should, because of the potential risk of stress corrosion cracking, be constructed of steel with a tensile strength of < 45 N/mm^2. After construction the tank should be heat treated (stress relieved). The tanks have to be inspected periodically for cracks.

2. Flare-stacks on top of refrigerated ammonia storage may cause vapour-cloud explosions. The flare-stacks should be situated in an enclosure at ground level and be at a safe distance from the plant and tank.

3. For the safe operation of fertilizer plants, it is necessary that the plant designers and plant operators should co-operate during the design and start-up stages. A training programme for operators should be included in the contract for the new plant.

Session IV and V (part one): Case histories

1. A substantial number of failures or accidents are caused by a lack of adequately qualified and trained personnel, mainly owing to pressure from the trade unions regarding promotional policies for personnel. The safety problems involved with the recruitment of adequately qualified and trained personnel should be discussed with the labour unions and their co-operation requested for the sake of the general safety of the plant.

2. The CO_2 compressors and carbamate pumps of urea plants frequently fail, and there is a need for exchange of experiences and views on this subject. A one-day symposium on CO_2 compressors and carbamate pump experiences would be very helpful. It was suggested that FAI take the initiative.

3. Accidents are a major cause of plant shut-downs. Management as well as operators can learn a lot from these accidents on how to improve plant operation. An accident reporting scheme should be developed. The accidents should be reported on a standardized form to a central organization in the region, where the information would be available to everyone. For instance, FAI may do this for India.

4. Some of the accidents in fertilizer plants may be attributed to plant modifications. In most of these cases the modifications had been carried out without consulting the safety engineer. Procedures should be established in which it should be pointed out which departments have to be consulted in case of plant modifications and repairs, and the safety department should certify that the modification or repair has been checked.

5. In well-organized plants instructions dealing with operational, emergency shut-downs, and safety and emergency procedures are available. Nevertheless, the management should check the functioning of safety procedures by periodic "safety audits". It may be necessary to invite qualified external experts to assist in the audit team.

Session VI: Handling and storage

1. Refrigerated storages of liquid ammonia have to be constructed according to generally acceptable standards such as API 620 or BS 4741. However, these standards and most of the available codes of safety practice do not give figures for safe distances to populated areas. More detailed studies should be carried out. For the time being, companies are urged to carry out risk evaluation analyses for their local situations.

2. Considering the size of the refrigerated tanks and bearing in mind the safety of people in downwind areas, it is recommended that such tanks be constructed fully double-walled i.e. that the outer wall is fully able to resist the static heat of the stored ammonia.

Session VII: General considerations

1. The UNIDO/FAI Interregional Meeting held in 1976 and this Meeting have been shown to meet a need for useful information and an exchange of views between technical experts in the various fields of the fertilizer industries in the developing countries. UNIDO should organize interregional meetings on topics related to safety in the fertilizer industries once in three years. The next meeting should be convened in 1983. The value of these interregional meetings would be improved if contractors were also invited to participate.

II. ORGANIZATION OF THE MEETING

The Meeting was opened by the Executive Director of the Fertilizer Association of India, Satya Nand. In the inaugural session, the Minister of State, Dalbir Singh, addressed the audience.

Thirty-one technical papers were presented and discussed (see annex). The papers submitted were grouped on the basis of content and presented under the following themes:

Session I:	Design considerations
Session II:	Operational and maintenance considerations
Session III:	Safety in ammonia plants and related facilities
Sessions IV-V:	Case histories including country reports
Session VI:	Handling storage
Session VII:	General considerations

The complete papers and proceedings will be published by FAI and can be obtained on request to:

Fertilizer Association of India
Near Jawaharlal Nehru University
New Delhi 110067
India

The Meeting was attended by approximately 100 delegates from the following 17 countries and 2 UNIDO officials and ISMA/APEA representatives:

Bangladesh
Brazil
Cyprus
France
Germany, Federal Republic of
Hungary
India
Italy
Kuwait
Mexico
Netherlands
Romania
Saudi Arabi
Sri Lanka
Thailand
United Kingdom of Great Britain and Northern Ireland
United States of America

III. SUMMARY OF PAPERS AND DISCUSSIONS

Session I: Design considerations

It was stated that with the increasing emphasis on reducing the production costs of fertilizers the number of single stream fertilizer plants with a high capacity was increasing. To be economical those plants must have a high degree of optimization and on-stream factor. That requirement stressed the reliability of the instrumentation, which had to ensure proper functioning of the equipment in order to prevent damage to the equipment, loss of production, injuries or loss of personnel. The basis of a reliable system was the use of well-proven instruments with good records. Equally important was that the various associated back-up systems were well designed and installed. The following back-up systems were distinguished and discussed at the Meeting:

Electrical power supply for electrically actuated instruments and protective interlocks

Air supply for pneumatically actuated instruments

Redundancy in measurements, control loops and interlock circuits

Fail-safe feature for control loops

Provisions for "forewarning" and "pre-alarm" techniques

Safeguards against inadvertent slips by operators and maintenance staff

While dealing with those systems it was remarked that redundancy of instruments should be avoided because it might cause plant shut-down. That warning was based on experimental data which illustrated how carefully the instrument system had to be designed at an optimum requirement level. For that reason it was recommended that experienced operating and maintenance personnel should be involved at a very early stage of the plant design. That was necessary also because design consultants generally had no operating experience. In that connection, it was recommended that the plant owners should clearly specify their company's policy in respect of operating and maintenance. If the plant owners intended to insure the plant to be built, the best practice was for the insurance company also to check the planned system.

The CO_2-recovery from ammonia plants usually contained very small quantities of hydrogen and nitrogen. When using that CO_2 as feed for urea plants, the possibility should be checked of its accumulating in the equipment together with the oxygen added to the urea process to prevent corrosion. The potential points of accumulation should be designed to allow only a small volume to accumulate in order to reduce the eventual explosion to such an extent that no damage to the equipment could occur. On the other hand it was recommended that the CO_2 feed should be cleaned of hydrogen before being used in the urea plant.

Session II: Operational and maintenance considerations

It was noted that frequently plant shut-downs were caused by corrosion of equipment. Corrosion of fertilizer units was generally less severe than that in sulphuric or phosphoric acid plants. The corrosive spots of a fertilizer plant were located where liquid phases were handled, for example, the preneutralizer or granulation drum. The rate of corrosion at those spots depended on the type of fertilizer being produced and the pH; for example, in the presence of chloride-ions and a low pH corrosion was very severe. That was also the case with phosphoric (wet) acid plants where the phosphoric acid was contaminated with F^+, Cl^- and SO_4^{--}-ions.

In that connection, the abrasion- and pitting-corrosion in the phosphoric acid was discussed. It was explained that those types of corrosion could be brought down to acceptable levels if appropriate materials of construction or lining were chosen. The success of those construction materials depended strongly on the skilful way they were applied when constructed. Ca^{++}-ions had an inhibiting effect on the corrosion mentioned above, however, the addition of Ca^{++}-ions was not desirable. There was no experience with the addition of NH_3^+-ions.

Since impurities in the phosphoric acid caused the corrosion, it might be possible to control that, economically, by using special grades of phosphate rock with lower contents of the various impurities and processing that grade in equipment constructed of cheaper materials.

Predictive maintenance was regarded as a valuable tool in reducing the possible failures of equipment. Basic to that practice was the gathering of the necessary information with the aid of special testing methods and apparatus. With the development of microprocessors, highly advanced portable test apparatus became available. That reliable equipment was able to analyse vibration characteristics of rotating machinery or corrosion characteristics etc. The incorporation of predictive maintenance based on those analyses would keep the plant running as long as possible.

A focus of discussion was the way that testing or inspection should be organized within the company. Preferably it should be done by an inspection department, but one firm had good experience with vibration analyses carried out by the mechanics and the operators of the plant.

The session was concluded with a discussion on safety in the design and construction of industrial structures. A systematic approach was recommended. A warning was given on the use of asbestos. In most Western countries the use of asbestos was forbidden because of the damaging effect on the lungs. Personnel working with asbestos-containing construction materials must be protected by special dust masks.

Session III: Safety in ammonia plants and related facilities

The session started with a review of the Silver Anniversary Symposium on Safety in Ammonia Plants and Related Facilities. That Symposium was very successful. Over 400 persons attended from over 20 different countries. A review of the Symposium was given and the conference papers made available so that participants of the Meeting could obtain copies.

Extensive discussion arose on the safety aspects of large tonnage ammonia storage installations. In case of major spills a dyke around the tank helped to restrict the liquid ammonia within a certain area and consequently the rate of evaporation. Experiments had shown that application of medium foam over the ammonia pool would decrease the evaporation of the cold liquid ammonia. It was further explained that pools of liquid ammonia should never be combatted with water. The heat development, due to the reaction between the water and the ammonia, enhanced the evaporation of the liquid ammonia enormously.

Stress corrosion cracking was still a problem of pressurized storages. One of the major factors causing that type of corrosion was small amounts of oxygen (a few ppm might be enough). The addition of 0.2% DM-water was shown not to bar all the stress corrosion cracking of those pressure vessels. More research was necessary to discover all the factors that started that type of corrosion. It was emphasized that heat treatment-stress relief of the tank after construction was very important for its performance. Steels with a high tensile strength (>45 N/mm^2) were more sensitive to stress corrosion cracking. Tanks constructed of such steels should be inspected more frequently, for example, once a year.

Refrigerated storage tanks should be built according to sound standards such as those given in API 620 or BS 4741. After construction the tanks should be hydro tested up to a maximum storage level. The prevailing opinion was that new tanks should be constructed with double walls. Recently various tanks, which were of the single-wall type, had been provided with a second wall that was capable of sustaining the full static load in case of a failure of the primary barrier.

Flare-stacks for pressure build up in the refrigerated storage were generally mounted at a certain height above the tanks but, because of the risk of vapour cloud explosion, ground flares with bunds at a safe distance from the tank were recommended.

It was recommended that the first inspection of the large refrigerated tanks take place after 6 years. In some countries that period was legally fixed at 12 years. That inspection should include magneflux crack detection of all the welds of the floor plates, at least 50% of the welds of the shell plates and a visual inspection of all the plates etc. After the first inspection, the next inspection might be fixed at 12 years, depending on the results of the first inspection.

Finally it was concluded that large-scale storage of ammonia was safe when operation and maintenance were carried out by properly trained and skilled teams.

Session IV and V (part one): Case histories

It was stated that accidents or failures were an important share of the production loss in process industries. Often they were accompanied by loss of life and equipment. In those aspects the fertilizer industry was not an exception. In developing countries, especially, the consequences might be severe owing to the need to wait for the delivery of the spare parts of the equipment involved.

In the course of the two sessions eight case histories were presented.

Many failures or accidents resulted from a lack of adequately qualified and trained operating staff, mainly due to pressure from the trade unions on the promotional policies within firms. It was concluded that training and courses or feedback from seminars improved knowledge and understanding of the production process. One delegate found a BSc degree necessary for staff personnel. Even at that level it was useful to give refresher courses to staff every six months.

Excessive corrosion, insufficient preventive maintenance and safety inspections were considered important sources of failures and production losses. More attention should be paid to inspection test standards and test equipment. It was shown that corrosion problems could be reduced substantially by using inhibitors containing chromate, phosphate and zinc (20-40 ppm) in the cooling water circuits of ammonia and urea plants. Improvements were also obtained by using biocides to control the troublesome microbiological organisms in the cooling water. The application of protective coatings for heat exchangers or coolers was very successful; most of the coatings used were of the phenol/epoxy type and applied in a layer thickness of about 0.25 mm. The application of those organic coatings was limited to temperatures well below 200°C.

For protection of the heat exchangers in the primary reformer section with temperatures above 200°C good results were obtained with metallic coatings of aluminium. Since one layer of aluminium coating is too porous, several layers were necessary to obtain good protection. Such protection applied at the construction stage was found to be more beneficial than that done at a later stage, after the plant had been in service for some time.

In the course of the discussions the need for additional safety equipment came up. The critical points in the process could be allocated on the basis of a failure analysis. Further analyses might lead to a proposal for additional instrumentation such as pressure gauges and thermal couples. To safeguard those critical points against damage the use of frangible discs, safety relief valves, manually operated valves etc. might be considered.

It was realized that those additional safety instruments or equipment could solve all the safety problems. Besides the hardware, the operating staff should be provided with clearly written instructions dealing with the operational, emergency shut-down and safety and emergency procedures in general. Those procedures should be a part of a training programme, which must be repeated periodically.

The information transferred between shifts was also regarded as a potential source for unnecessary failure. According to circumstances, especially if there was trouble with the equipment, it might be forgotten to transfer information between shifts. An improvement might be to make use of a standard form whereby the operator was forced to fill in his shift report for each section of the process. Moreover it would have to be ensured that one shift left only after the next had taken full command of the plant or section. A number of accidents with CO_2-compressors were regarded as being caused by the handing over of shifts.

In general CO_2-compressors and also the carbamate pumps of urea plants were shown to require continuous attention. Failures of such advanced equipment resulted generally in long shut-down periods and consequently much loss of production.

After the extensive discussions on the details of the accidents with reciprocating plunger pumps, it was concluded that there was a clear need for an exchange of experience. It was suggested that FAI should organize a one-day symposium in the near future, specially devoted to those pumps.

To improve safety in the plants the delegates were asked their views on safety audits. Some companies had had experience with safety audits. Successful audits were only possible if the audit team had the necessary expertise for the work; it was sometimes necessary to invite qualified external experts. Before starting a safety audit, the team must be clearly informed on the safety policy of the company, and it was helpful if a data bank of accidents was available.

It was pointed out that the Manufacturers Chemists Association (USA), had issued a brochure giving guidelines for safety audits in chemical plants.[1/] The prevailing opinion was that safety records could be much improved by carrying out safety audits. However, it was emphasized that safety efforts could only be successful if the management was fully aware of its responsibilities not only for the production but also for the safety of the plant and personnel.

Some delegates wondered if UNIDO could take the initiative in the matter of safety audits. A better approach seemed to be a regional one, for example, FAI could take the lead for India. For about 15 years ISMA/APEA had been working on an accident reporting scheme, mainly for the European area. To prevent difficulties with insurance, in the first stage a provisional accident report with limited information was used. After the insurance claims had been settled, a final accident report was issued.

1/ <u>Safety Guide</u> (Washington, D.C., Manufacturers Chemists Association, 1978).

Session V (part two): Country reports

Bangladesh

The delegate of Bangladesh explained the importance of safety in the fertilizer industries. Small accidents might lead to serious damage to the environment and loss of lives. Loss of life or major injuries could not be compensated for by payment. It should be realized that human failures would always remain and consequently 100% safety would never exist.

A review was given of the fertilizer industries in Bangladesh. A total of eight plants were on-stream producing ammonia, urea, ammonium sulphate and triple superphosphate of which urea takes by far the biggest share.

Safety was an integral part of the activities of the companies. Each plant had a central safety committee chaired by the plant manager. That committee consisted of the heads of the departments and two representatives of the Employee's Union. The safety committee met once a month to review and recommend safety procedures. There was close co-operation with the personnel.

The committee reported to the functional directors for Engineering and Personnel and to the Board of Managing Directors of the corporation. The central safety committee had clear terms of reference for its task within the company. The central safety committee was supported in its work by departmental safety squads and volunteers.

The risk of accidental loss of equipment or lives was covered by various insurance companies.

The delegate of Bangladesh concluded by stressing the importance of starting safety considerations at an early stage of design of the plant. After commissioning the plant safety surveys should be carried out regularly. Plant modifications should be carefully examined for safety aspects before being carried out. Training of personnel in safety procedures and safety information on accidents should be done periodically.

Brazil

The delegate of Brazil reviewed the safety procedures for the explosives used for loosening piles of caked MAP and superphosphate at Quimbrasil S/A. It was emphasized that the practice was restricted to storages used only for those products. The use of explosives for loosening nitrate-containing fertilizers was strictly forbidden.

The safety procedures gave rules for all phases of the work including storage, transport, safety conditions prior and during blasting operations, control after firing and strict rules for the workers. Special attention was paid to weather conditions, such as lightning and thunder, where electrostatic charges were involved. Under such conditions blasting work was not allowed and the work must be stopped immediately. During work, the personnel were forbidden to carry cigarettes, matches, lighters or metallic objects.

Cyprus

The delegate of Cyprus explained that the first heavy chemical industry was currently under construction at the plant. It included a sulphuric acid plant which would be commissioned the following April. Also under construction were plants for phosphoric acid, NPK , ammonium sulphate and ammonium phosphate. Phosphate rock and ammonia had to be imported. Ammonia was stored in three semi-refrigerated spherical tanks with a total capacity of 5,400 tons of ammonia. All acidic and harmful liquid effluents were collected and neutralized in a treatment unit before disposal.

A review was given of the processes employed, the utilities and the facilities planned.

Hungary

The delegate of Hungary explained that the experience dealt with in his report were gained at the fertilizer division of the Chemical Works of Borsod. Production included CAN containing 26-28% N, ammonium sulphate, a byproduct of the caprolactan production and urea. Besides those main products, smaller quantities of ammonia and urea-ammonium nitrate solutions 30% N were being marketed.

Implemented safety procedures and measures for production, storage, and distribution were at a high level, so no problems had occurred that would cause significant accidents, fires or damage. Personnel were provided with written procedures and periodically trained. That also included fire drill and the use of personal protection in emergencies. A detailed summary of preventive measures was given.

Kuwait

The safety problems of the fertilizer division of the Petro-Chemical Industries Company were reviewed. The division produced mainly ammonia and urea, but also sulphuric acid and ammonium sulphate. Those fertilizer plants suffered from different types of safety problems, some of which were owing to the special nature of the local conditions. The review was restricted to the major problems in production, transportation and storage of ammonia and urea. Also some case histories were given to illustrate the problems. Corrosion, especially in the urea plant, was one of the main sources of failures and accidents. To counteract that problem a schedule for inspection had been established. Depending on the degree of hazard of the product handled, the pipelines were grouped into three classes. For each class an inspection frequency had been fixed once in 2, 4 or 6 years. There were many problems with check valves which had led to instructions for periodic controls. Attention was being paid to the 4.5 km ammonia transfer-line to the harbour. With the aid of an automatic shut-down system, that transfer-line was protected against major leakages. It was explained that the system was so designed that no excessive surge pressure would arise in an emergency stop. Still, serious problems were met on the coast: there had been frequent collisions over the past 10 years. A multidiscipline committee had been established and was studying measures to be taken. To solve the problems and consequently improve production and safety, the following points were being studied:

(a) The lack of spare parts at the local market influenced the decision whether to stop or run the plant while it was possibly unsafe;

(b) The shortage of skilled workers;

(c) The many different languages of the personnel;

(d) The supply of substandard materials from the manufacturers.

Mexico

The delegate of Mexico reviewed two government-owned fertilizer industries: Fertimex and Pemex. Both companies ran several fertilizer complexes throughout the country producing annually 4 million tons of fertilizer products and 3 million tons of ammonia, respectively. Large extensions were under design or were being constructed over the next five years.

Mexico had a good safety legislation which was controlled by the Ministry of Labour. Periodic inspections were carried out by the safety committees within the plants. The plant safety committees consisted of representatives of the employees, employers and the Ministry of Labour. Also important in the safety legislation was the role of the Mexican Institute of Social Security, which cared for the health of the workers and their families. In case of accidents the institute quotas for the employers would increase. Accidents on the workfloor were of major concern to all industries.

Fertimex and Pemex strictly followed legislation and incorporated safety features at a very early stage of the design and construction. Sound standards, specifications and codes of safe practices were applied. Design and construction were carried out under the supervision of qualified engineers with special attention to safety. If construction and materials of construction were safe, most of the potential accidents were prevented. The accidents that had happened were mainly caused by human failures.

The top management of the industries concerned felt the complete safety of the company was a regular part of their responsibilities. The plant management dealt with and ensured the safety of operations. Each plant had a safety department giving advice, training and personnel and assisting the safety groups and committees in their tasks. Care was taken to observe safety regulations and safety procedures. A review was given of the main safety tasks and responsibilities of the plant management and the safety departments.

The accident records of the previous 10 years showed that most accidents were caused by human failure. Realizing that, and the low educational level of the new employees, the training of new personnel in their duties and safety aspects had been given the highest priority for the next five years.

The delegate spoke of a recent ammonia accident in Mexico that had happened during loading operations at a privately owned site. There had been fatalities, but no details were available as the accident was still being investigated.

Romania

The delegate of Romania explained that his report was a review of the experience obtained during a period of from 10 to 12 years in urea plants all over Romania. Accidents and failures had resulted in a series of measures being taken that had increased the safety in operation and on-stream factor of urea plants in Romania.

It was explained that corrosion in the plants had been very serious in the past and mainly affected those parts where NH_3/CO_2 mixtures were present. Frequent safety inspections and replacement of the affected parts had reduced the failures and accidents to an acceptable level. Check procedures were also carried out on all valves in the NH_3/CO_2 circuits, for example, the one-way valves were checked twice a year.

By installing additional instrumentation such as pressure gauges or flow controllers, plugging due to crystallization of urea or carbamate could be signaled at an early stage so that the necessary action could be taken. The delegate recommended consideration of the reviewed measures by the other participants when faced with similar problems.

Saudi Arabia

The delegate of Saudi Arabia reviewed the ammonia and urea plant of the Saudi Arabian Fertilizer Company (SAFCO) located in Damman. Both processes were based on a Chemico design having respectively a capacity of 600 tons/day of ammonia and 1,000 tons/day of urea. From the commissioning of the plant, in 1969, up to 1974, the urea production had reached only half its designed capacity. Several factors contributed to that poor result including design problems, poor operating and maintenance practices, failures, accidents and unstable ineffective management. After 1974 the management reorganized the personnel including managerial positions. Plant modifications were undertaken to remove bottle-necks and new safety procedures implemented for plant and personnel.

A systematic approach led to plant modifications, for example, the reformer furnace was improved including material changes of the pigtails and manifold; the urea plant was revamped by replacing the crystallization section with two falling film evaporators that produced concentrated urea solutions for the prilling tower. More modifications are under way, not only to improve the processing conditions but also the working conditions of the personnel.

He stated that a series of improved operational, maintenance and safety procedures had been implemented. Of those procedures pollution control was emphasized. Effluents were regularly checked and actions taken if the fixed limits were surpassed. The personnel as well as the people in the surrounding districts were very alert to pollution and took action immediately when pollution occurred.

The on-stream factor was currently about 90%, reaching 88-98% of its production capacity.

The review showed how a company with a bad record could be improved to be a very efficient and successful enterprise comparable to any similar plant elsewhere in the world.

Sri Lanka

The delegate of Sri Lanka stated that up till then, his country had been fully dependent on fertilizer imports. The country hoped to commission an ammonia/urea plant at the end of the year that was expected to provide for the entire urea needs of the country. The importation, storage, blending and distribution of fertilizers were in the hands of the Ceylon Fertilizer Corporation and Colombo Commercial Company (Fertilizers) Ltd. The State Fertilizer Manufacturing Corporation was responsible for the production of fertilizers.

The State Fertilizer Manufacturing Corporation had incorporated all the necessary safety requirements and facilities from the design and construction phase of the new ammonia/urea plant. Owing to its location it was necessary to set up a works fire brigade. The plant had an underground network of waterpipe lines with hydrants and monitors for fire fighting at the various spots and a fire water-storage tank of 7,500 m^3 capacity. The plant was also provided with telephone communications to the Fire Station Control Room and an alarm system. Emergency procedures for the fire brigade had been set up and it trained regularly. All employees of the plant were trained in safety courses before taking up their respective duties. The Safety Department ran its own safety stores and provided all personnel with the necessary protective wear such as helmets, overalls, goggles and gloves. Breathing equipment was available throughout the plant for emergencies.

The Safety Department had issued a system of clearance certificates (work permits) for all maintenance and allied work on plants and machinery. A plan for safety inspections and safety audits was being developed.

Thailand

The report from Thailand was based on experience obtained mainly from Thail Central Chemicals Co. Ltd. That company produced mainly ammonia, fertilizer grade ammonium nitrate and ammonium nitrate containing mixtures.

A review was given of the prevailing safety rules on all phases of production, storage and transport.

Session VI: Handling and storage

Session VI included the presentation of two extensive papers dealing with safety aspects in the handling and storage of liquid ammonia, including ammoniacal solutions, and nitrophosphate fertilizers.

The safety aspects of the storage of liquid ammonia were introduced with a review on the technical features of fully and semi-refrigerated storage and the storage of pressurized ammonia. A summary was given of the safety devices and equipment for the storage tanks. In that connection the legal rules of the Federal Republic of Germany and the recommendations of ISMA/APEA were detailed. Location and safe distance rules were explained in relation to the size of the storage. All modes of transport of liquid ammonia were summarized and reviewed together with the existing international transport codes such as RID, ADR and ADNR. Special attention was paid to transport via pipelines.

The effect of ammonia leakages on the population in the downwind area was discussed. The MCA-value of 25 ppm ammonia, internationally accepted for safe working conditions, could be used as criteria for population safety in an emergency. On the basis of those criteria, the distance to inhabited districts and vapour dispersion calculations, the maximum allowable accidental release of ammonia could be calculated. From those results dividing into sections the ammonia pipelines with quick closing valves might be considered. The volume eventually released from the pipeline between two valves should not be higher than the above calculated maximum allowable release. The valves should act automatically and be remote controlled. The problem of safe distances from ammonia plants to populated areas required more detailed studies being made as no standardized rules were available.

The testing of the ammonia handling system for pipelines was once a year on a voluntary basis. It was recommended that pressurized storage tanks be inspected every 5 or 6 years and refrigerated storage tanks every 12 years. For a fully double-walled tank, this inspection period might be even longer.

Flexible hoses for ammonia must have a bursting strength quality of five times the maximum expectable working pressure. The hoses must be inspected at least once a year and tested at 1½ times the maximum expectable working pressure.

An extensive discussion was held on safety relief valves on rail-tankers. In Europe that was not allowed owing to safety reasons in collisions and capsizing of the tanks. For the same reason, the transfer connections were below the tanks. In India, all connections were on top of the tank and protected by a dome. In case of overfilling the tank safety relief valves could prevent a failure of the tank.

The discussions on the subject were concluded with a general warning to evaluate carefully all the risks involved when designing new facilities. It had to be considered that the health and safety of the population of the surrounding districts were involved.

The hazards of and safety measures for the handling and storage of nitro-phosphate fertilizers were discussed and a brief description given of the production process of those nitro-phosphates. Also, a detailed review was given of the physical and chemical properties of ammonium nitrate and of the decomposition reactions and the phenomenon "cigar burning". Hazard characteristics were illustrated by a number of case histories of accidents and a summary of remedial measures and safety appliances was given. Most of those measures were aimed at the prevention and fighting of fires.

In India, the number of decomposition accidents had decreased during the last few years. The cause was presumed to be the lowering of storage piles. In the past, storage to much higher heights was necessary owing to lack of storage space. Some delegates thought the use of foreign trace elements enhanced the risk of decomposition accidents. It was known that, for example, copper strongly catalysed the decomposition of nitrates. In India, there was no experience with the use of copper in fertilizers as micro-mutrient. Some relevant publications 2/ were handed over to the Chairman.

Session VII: General considerations

The last session was opened by the Chairman with a short introduction in which he pointed out that the discussions in the previous six sessions had made it clear that the Meeting had been very successful and should be held once every three years.

The first paper of the session dealt with the safety aspects of production, storage and transport of fertilizers containing ammonium nitrate. A hazard profile of ammonium-nitrate containing fertilizers was given noting detonation, self-sustaining decomposition, spontaneous self-heating, fume-off and oxidizing capacity. The existing international transport and safety regulations were

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2/ G. Perbal, "The thermal stability of fertilizers containing ammonium nitrate", Proceedings No.124. The paper was presented at the Fertilizer Society of London on 25 November 1971; three papers were presented by G. Perbal, J. Killeen and V.P. England on safety in the works, Proceedings No.137, on 22 November 1973.

reviewed and a summary made of the hazard classification of those products. The test methods necessary to determine the hazard classification were explained.

Special attention was paid to the self-heating processes in storage and in rotary dryers. The temperature limits recommended for ammoniators or rotary dryers were to be used for new designs; existing equipment might be designed for higher temperatures. For equipment with high operating temperatures additional safety measures were recommended such as the installation of permanently fixed water-guns at the dryer. For the purpose of rapid evacuation in emergencies with the dryer, an alarm signal in the building might be very helpful. Spontaneous heating might develop especially in mixed fertilizers of lower grade i.e. with a high P_2O_5 % and with a pH<4.0. Phosphates of different origin contained various percentages of organic material. At the laboratory the organic content might be estimated by measuring the CO_2 content of the gas resulting from the burning of the sample in an oxygen stream.

It was explained that UAN-solutions as such were non-hazardous. The problems developed when leakage of the solution into the insulation of the equipment occurred. If that insulation was steam traced, the solution would desiccate and chemical changes would occur that might lead to an explosion of the desiccated substance in the insulation.

The second paper was introduced with a review of the measures taken to protect plant personnel against toxic substance on the work-floor. A detailed description was given of the organization and the facilities necessary for a successful occupational health programme. Medical examinations of the personnel had to be established and held regularly. The toxicity of all substances including raw materials, intermediates, and products etc. should be evaluated. For a number of products the nature of the hazardous properties were reviewed. Details were given of the safety equipment to be used when handling those products. The scheme of preventive measures for plant personnel appeared to be still in development and had not been tested.

Annex

PAPERS PRESENTED TO THE MEETING

Session I: Design considerations

Chairman: Mr. D.G. Rao, Ministry of P and C

Rapporteur: Mr. K. Tripathi, SPIC

Back Up System for Safe Instrumentation in Fertilizer Plants
C.D. Amudachari, FPDIL, India

Environmental Safeguard and Plant Protection in the Operation of Centrifugal Compressors in Large Ammonia Plants
Ludovico Mariani, APEA/Technimont, Italy

Explosion Hazards in Urea Plants and Its Prevention
F. Dooyerweerd, APEA/Stamicarbon, Netherlands

Hazards and Their Prevention in Nitric Acid and Calcium Ammonium Nitrate Plants
M.R. Agarwal, UNIDO Consultant, RCF, India

Session II: Operational and maintenance considerations

Chairman: Mr. B.S. Kakkar, NFL, Nangal

Rapporteur: Mr. R. Raju, MFL

Factors Governing Corrosion during the Safe Production of Sulphuric Acid and Phosporic Acid
Pierre Becker, UNIDO Consultant, ISMA/COFAZ, France

Predictive Maintenance Avoids Failures
T.R. Sabapathy and V. Sitaraman, MFL, Madras, India

Safety of Structures and Buildings
S. Mathevan Pillai and N. Unnikrishnan, FEDO, India

Session III: Safety in ammonia plants and related facilities

Chairman: Mr. L.R. Talwar, IFFCO

Rapporteur: Mr. K. Manoharan, IFFCO-Phulpur

Ammonia Plant Safety - A review of the Silver Anniversary Symposium on Safety in Ammonia Plants and Related Facilities
Tracy A. Sandow, UNIDO Consultant, IMC, USA
(To be presented by F.T. Nielsson)

Safety Aspects of Large Tonnage Ammonia Storage Installations
K.T. Thampi, Uhde, India

Session IV: Case histories

Chairman: Mr. V.R.R. Gupta, MFL

Rapporteur: Mr. M.R. Dubey, RCF

Explosion in CO_2 Absorber
S.P. Gupta and I.J. Ohri, IFFCO, India

Explosion in Carbon Slurry Tank
B.S. Kakkar and Prem Kumar, NFL, India

Fire Incidents in Composite Ammonia Plant at FACT
K. Sadanandan Pillai, FACT, India

Fire in Nitrogen Wash Unit in Nangal Unit of NFL
B.S. Kakkar and C.L. Kaul, NFL, India

Corrosion in Ammonia and Urea Plants at IFFCO-Kalol Unit
K.K. Therat and A.K. Gupta, IFFCO, India

Session V (part one): Case histories

Chairman: Mr. A. Qidwai, SAFCO

Rapporteur: Mr. C.S. Shanmugam, ZACL

Experiences with Protective Coatings for Heat Exchanges/Coolers Technoeconomics
S.C. Purj and K.J. Koruth, IEL, India

Breakdown of CO_2 Compressor at Barauni
P.K. Gupta, HFC, Barauni, India

Case Histories of Failures in Carbamate Pumps and CO_2 Compressors
V. Charandas, B.D. Rehani and M.D. Buch, GSFC, India

Session V (part two): Country reports

Chairman: Mr. A. Qidwai, SAFCO

Rapporteur: Mr. C.S. Shanmugam, ZACL

Bangladesh

Country paper Bangladesh
B.K. Mozumdar, Urea Fertilizer Factory, Ghorasal, Dacca, Bangladesh

Brazil

Safety Procedure Norm
Industrial Safety, Technical Division, Quimbrasil S/A, Brazil

Cyprus

Sulphuric Acid - Fertilizer Complex Cyprus
Dr. G.A. Charalambides BSe (Eng.) Ph.D. Cyprus

Hungary

Remarks about Some Questions of Safety of Production, Transportation and Storage of Nitrogeneous Fertilizers
István Adám, Chemical Works of Borsod, BVK, Hungary

Kuwait

Report on Safety in, Production and Storage Facilities
Mostafa H. AL-Mogheer, KSC, Kuwait

Mexico

Safety in the Mexican Fertilizer Industry
J.B. Rueda, Fert. Dep. Ministry of National Patrimony and Industrial Development, Mexico

Romania

Some Measures Concerning the Reliable Operation of Urea Plants
Saveluc Neculai, Industrial Central for Chemical Fertilizers, Craiova, Romania

Saudi Arabia

In House Team Improves Safety Production and Profitability
Saleh Ibrahim Quaraidis, SAFCO, Damman, Saudi Arabia

Sri Lanka

Safety Measures in Sri Lanka's Fertilizer Industry
E.G.P. Kalpage, State Fertilizer Manufacturing Corporation, Sri Lanka

Thailand

Safety in Production, Transportation and Storage of Fertilizers
Proyurasak Jalayanateja, Thai Central Chemical Co. Ltd., Bangkok, Thailand

Session VI: Handling and storage

Chairman: Mr. V.R. Joharapurkar, IFFCO, Kalol

Rapporteur: Mr. P. Jayaraman, FACT, Udyogamandal

Safety Systems Involved in Handling, Storage and Transportation of Liquid Ammonia Including Ammoniacal Solutions
Wolfgang Rall, UNIDO Consultant, APEA/BASF, FRG

Hazards and Safety in Handling and Storage of Nitrophosphate Fertilizers
M.R. Agarwal and N.K. Sharma, RCF, India

Session VII: General considerations

Chairman: Mr. M.C. Verghese

Rapporteur: Mr. P. Anandan, HFC, Durgapur

Safety Aspects of Production, Storage and Transport of Fertilizers Containing Ammonium Nitrate
G. Perbal, UNIDO Consultant, APEA/UKF, Netherlands

Toxicology - Preventive Measures for Plant Personnel
N.K. Seturam, IEL, India

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7