ANSI K 61.1

Ammonia System
27 P&IDs 190 sections

Recommend HazOp

# PROCESS SAFETY ANALYSIS IN A PHOSPHATE PLANT

IMC FERTILIZER, INC.

By: David M. Sabatino

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
CLEARWATER CONVENTION
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## Introduction

A new OSHA standard that went into effect on May 26, 1992, requires all facilities handling highly hazardous materials to implement Process Safety Management. Anhydrous ammonia, sulfur dioxide, sulfur trioxide and chlorine handled at IMC Fertilizer's New Wales plant fall under this OSHA standard. IMC Fertilizer has a settlement agreement with OSHA which requires the process hazard analysis to be completed on an accelerated schedule.

IMCF has made significant progress in the implementation of process hazard analysis. The process safety management requirements and experience at IMCF will be discussed.

## Background

OSHA cites recent major incidents involving highly hazardous chemicals as well as incidents not widely publicized as the reason for the need for legislation and regulations directed toward eliminating or minimizing the potential for such incidents.

Major incidents cited included:

1984 Bhopal incident that resulted in more than 2000 deaths

1989 Phillips 66 incident that resulted in 24 deaths and 132 injuries

1990 BASF incident that resulted in 2 deaths and 41 injuries

1991 IMC incident that resulted in 8 deaths and more than 100 injuries

OSHA conducted inspections of a small segment of the chemical industry to examine industry practices for the prevention of disastrous releases and the mitigation of the effects of releases. OSHA concluded that a comprehensive inspection was needed that included plant physical conditions and management systems.

The Clean Air Act Amendments were placed into law in 1990 and required OSHA to develop a chemical process safety standard to prevent accidental releases of chemicals that could harm employees.

OSHA implemented the Process Safety Management standard, 29 CFR Part 1910.119, effective May 26, 1992. The purpose of the standard is to prevent or minimize the consequences of a catastrophic release of a chemical. It applies to all processes using a chemical at or exceeding the threshold quantity as established by OSHA. Anhydrous ammonia, sulfur dioxide, sulfur trioxide and chlorine, which are handled at IMC Fertilizer's New Wales plant, are on the OSHA list of highly hazardous chemicals.

Process safety reviews are not new and have been used throughout the chemical process industry to improve process safety. The OSHA standard not only makes process safety management mandatory for hazardous chemicals; it also gives specific requirements for employee participation, process information and process hazard analysis.

Process Hazard Management Requirements

The Process Hazards Management standard requirements include: a written plan regarding employee participation, process safety information for chemical hazards, process technology, process equipment, process hazard analyses on the process, employee and contractor training, pre-startup safety reviews, mechanical integrity, hot work permits, management of change, incident investigation, emergency planning and response, and compliance audits.

The plan for employee participation is to make employees active participants in the implementation of the process safety management standard and provide access to all information resulting from the standard.

The chemical hazards information includes the chemical toxicity, permissible exposure limits, and the physical, reactive, corrosive, stability and incompatibility data for the chemical.

Process technology information includes process flow diagrams, process chemistry, maximum inventory, safe operating limits, and an evaluation of the consequences of deviations.

Equipment information includes materials of construction, P&ID's, electrical classifications, relief system design and design basis, ventilation system design, design codes and standards, material and energy balances for process built after May 26, 1992, safety systems, and documentation that equipment complies with recognized and accepted engineering practice.

Written operating procedures are required for each operating phase and are to be certified annually for accuracy. Safe work practices including lockout, confined space entry, line break, and personnel access control procedures are to be implemented. Compliance with the standard requirements is to be reviewed at least every three years.

The two areas that have the most impact are the requirements for employee training and process hazard analysis. All employees must be given initial training on the process or be certified as having
acquired the process knowledge skills. Training must be documented along with verification that the employee understood the training. Satisfying the requirements for process hazard analysis is a major effort and the remainder of the discussion will be on process hazard analysis.

## Process Hazard Analysis Requirements

The OSHA standard requires a process hazards analysis be completed on the process hardware, human factors and facility siting. The process hazard analysis may be conducted using, What-if, Checklist, Hazard and Operability Study, Failure Mode and Effect, Fault Tree, or an appropriate equivalent methodology.

The purpose of the process hazard analysis is to identify possible process deviations and the safeguards required to prevent the catastrophic release of a hazardous chemical.

The Process Hazard Analysis must address the hazards of the process, previous incidents which had a potential for catastrophic consequence, the engineering and administrative controls, the failure of engineering and administrative controls, facility siting, human factors, and an evaluation of the safety and health effects of the failure of controls on the employees.

The process hazards analysis is to be performed by a team with expertise in engineering, process operations knowledge of the specific process being evaluated, and knowledge in the process hazard analysis method being used.

A system must be established to address the findings, track and document recommendations, and communicate findings to all employees involved.

The OSHA standard requires that the process hazard analysis be completed on the following schedule:

25 % complete by May, 1994
50 % complete by May, 1995
75 % complete by May, 1996
100% complete by May, 1997

## Process Safety Management at IMCF's New Wales Plant

### Hazardous Chemicals at New Wales

At IMC Fertilizer's New Wales plant the hazardous chemicals present that are covered by the standard and their threshold quantities are:

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|---|---|
| Ammonia | 10,000 lbs |
| Chlorine | 1,500 lbs |
| Sulfur dioxide | 1,000 lbs |
| Sulfur trioxide | 1,000 lbs |

Ammonia is used for the production of diammonium phosphate and monoammonium phosphate. The ammonia is supplied by pipeline and railcar and is stored on site in 200 ton stationary tanks. Chlorine is used for water treatment and is stored in cylinders. Sulfur dioxide and sulfur trioxide are intermediate products in the conversion of sulfur to sulfuric acid.

### Process Safety Management Schedule

IMC Fertilizer has an Informal Settlement Agreement with OSHA as a result of the 1991 incident at the Angus nitroparaffins plant in Sterlington, LA which was operated by IMCF. The agreement is a legally binding document that specifies the actions required by IMCF. As part of the agreement with OSHA, the schedule for the IMCF New Wales plant process safety management is:

100 % complete November, 1994
Report to OSHA January, 1995
Response on all action items February, 1995
All action items completed January, 1996

IMCF is required to complete the process hazard analysis two and a half years ahead of the time set in the OSHA standard. The agreement also requires a process hazard review on sulfur dioxide and sulfur trioxide even though they may not be at the threshold quantity.

## Process Hazard Analysis

IMCF established a hazard review committee in 1985 to review toxic chemicals as part of the company's continuing efforts to improve safety. A process safety review sub-committee was formed in September 1991, prior to the final agreement with OSHA and 9 months prior to the OSHA Standard, to address the requirements of process safety management.

The sub-committee reviewed the process safety management requirements and began developing a plan for compliance. A Hazard and Operability (HAZOP) study was completed on an ammonia vaporizer in October 1991 to provide a better understanding of the review method. The HAZOP study method was selected as the method for the hardware process hazard analysis because it was more comprehensive than a checklist and the systematic approach was felt to be better than What-if. This was a significant decision since it would be the method for all of the process hazard analyses to follow.

Eight IMCF employee were trained as HAZOP Team Leaders in February of 1992. The Team Leaders consisted of three process engineers, two production superintendents, one maintenance engineer, one environmental supervisor and one mechanic who was also a union representative.

The HAZOP study method is a systematic method of brainstorming to identify and assess the significance of all the ways a process unit can malfunction or be improperly operated. The process P&ID's are divided into sections consisting of a single run of pipe, a vessel, or an operations unit such as pump, compressor, or heat exchanger. The guide words "high", "low", "no", "reverse" and "misdirected" are applied to process conditions of flow, pressure, temperature, and level to form a process deviation. Additional deviations include leak and rupture. The consequences of the deviation are determined and evaluated for significance. Possible causes are developed for all significant consequences and existing safeguards are determined. An action is recommended if the team determines that adequate safeguards are not present.

A permanent Process Safety Review Committee was formed in March 1992. The committee addressed several immediate goals of developing a standard procedure to guide all process hazard analyses, developing a tracking system, developing a process hardware change procedure, and developing a training program.

A procedure was developed to standardize the requirements for process hazard reviews. The procedure covers the team make up, responsibilities of team members, the review method, required information prior to starting a review, the factors to be addressed, and the contents of the final report.

The process hazard review requirements were divided into three main areas:

1. Hardware process hazard analysis

2. Operating procedure process hazard analysis to address human factors

3. Facility siting

A process hardware change flow diagram was developed to cover the steps required for the action items generated by the process hazard reviews and for field changes.

Three separate teams were formed to cover each hazard chemical, ammonia, chlorine, and $SO_2/SO_3$. Each team consisted of a trained team leader, trained scribe, production representative, production operator, instrumentation representative, and union representative/ maintenance mechanic. The team leader, scribe, production representative, and union representative/maintenance mechanic would be permanent members to give consistency and eventually experience to the team. The production operator and instrumentation representative would come from the area being covered to provide specific process knowledge.

<u>Ammonia Area Process Hazard Analysis</u>

The ammonia handling was the largest area to be covered and was separated into seven process areas:

1. Tampa Bay Pipeline from the plant boundary to the storage area

2. Ammonia storage bullets

3. Railcar unloading facility

4. MAP plant

5. DAP-1 plant

6. DAP-2E plant

7. DAP-2W plant

The P&ID's for each area had to be updated prior to starting a hardware process hazard review. The P&ID's were sectioned into line and equipment segments and a HAZOP analysis performed. The sectioning included at least one line section upstream and one line section downstream of an ammonia source. This resulted in phosphoric acid, sulfuric acid, steam and steam condensate lines being included in the ammonia process hazard analysis.

The criteria used to determine a consequence of concern were:

1. A fire or equipment damage resulting in an economic loss exceeding $1,000,000

2. Any explosion

3. Toxic material spills or releases which could injure employees

4. Any injury to contractors or off-site employees

5. Any potential lost time injury

The hardware HAZOP was started on the ammonia systems in March 1992. The Leader software supplied by JBF Associates, Inc. was used to make work sheets for the meetings and document the HAZOP results. The hazard reviews required frequent meetings. The team was most effective if meetings were kept to 4 hours or less with a short break every hour. Meetings were held twice a week. Keeping the meetings on the same days of the week and at the same time allowed team members to schedule their other job activities.

With six of the seven ammonia areas completed, the ammonia team has reviewed 190 process sections on 27 P&ID's taking 150 team hours and 900 manhours. Initial reviews required one to two hours per section. This time was eventually reduced to an average of 30 minutes per section as the team gained experience with the HAZOP method.

A total of five hours of preparation and two and half hours in documenting the review were required for every hour of meeting time for a total of 1350 manhours outside the team meetings. Preparation time included field verification of drawings, preparing process flow diagrams, drafting, sectioning the P&ID's, and gathering equipment information. Documentation time included preparing the meeting minutes and the final process hazard analysis report. The total time spent was 40% for preparation, 40% for the team meetings to

conduct the HAZOP review and 20% for documentation.

Important items to document the process hazard requirements that have become a standard practice are meeting attendance sheets, publishing meeting minutes and a detailed description of the reason and intent for each action item.

The ANSI standard K61.1, Safety Requirements for the Storage and Handling of Anhydrous Ammonia, and OSHA standard 1910.111, Storage and Handling of Anhydrous Ammonia, were used as the requirements for the proper design of the ammonia systems.

The $SO_2/SO_3$ and chlorine hardware process hazards reviews are complete and the facility siting review has been started on the chlorine system. Current plans are to use a What-if analysis for facility siting. Then the HAZOP method will be used on operating procedures as part of the human factors process hazard analysis.

## Conclusions

The process safety at IMCF is being improved as a result of the process hazard analyses being conducting on ammonia, chlorine, sulfur dioxide and sulfur trioxide processes. Action items found as a result of the reviews will reduce the probability of a hazardous chemical release and injury.

The hazard and operability, HAZOP, study method has been an effective way to conduct a hardware process hazard analysis on a fertilizer plant. The HAZOP method will also be used on operating procedures as part of the human factors process hazard analysis.

The process hazard analyses are a major undertaking requiring the time of personnel from all areas of the plant. A significant amount of time is required to update P&ID's and operating procedures which are the main reference documents for the hardware and human factors analysis.

## References

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