

4. QUANTITATIVE PLANT HAZARD AND RISK ASSESSMENT

4.1 KNO PLANTS 4, 5 AND 6 HAZOP STUDY AND PROCESS HAZARDS ANALYSIS REVALIDATIONS

HAZOP means Hazards and Operability Study which was adopted by OSHA on May 26, 1992, CFR 1910.119. This law established regulations for Process Safety Management which has now been globally accepted adopted as law or as best industry practice.

The HAZOP study analyzes how a plant is operated, constructed, and maintained. The main objective is the protection of the employees and third parties by minimizing the consequences of accidents involving hazardous chemicals.

Essential points relevant to the HAZOP include:

HAZARD: A situation with the potential for an accident with undesirable consequences. OSHA 29 CFR 1910.119, refers to catastrophic hazards involving loss of containment of flammable, combustible, toxic, or highly reactive materials which could affect workers.

ACCIDENTS (HAZARD SCENARIOS): Specific unplanned sequences of events that have undesirable consequence.

CONSEQUENCES: The potential impact of the accident in terms of the effects on people, property, or the environment.

OBJECTIVES OF HAZARD ANALYSIS (HAZOP): Identification of all credible accidents (hazard scenarios) that occur frequently, which could result in serious injury to an employee or the public, environmental impact, or property loss when they occur.

HAZOP METHODOLOGY: An approach involving a multi-disciplinary team identifying hazards by searching for deviations from design intent by brainstorming in a series of meetings. The team usually consists of people that are most familiar with the process that is to be studied, both technical and operational. The investigation focuses on deviations from design or operating intent for a process or system, in order to identify hazard or operability problems. This is accomplished by asking questions about the process, one section at a time. The sections are referred to as "Nodes".

NODE: A grouping of equipment, lines, vessels, and controls that can be studied by listing all deviations that may occur in the node. The team leader identifies the nodes in advance and confers with the team before they are studied.

INTENT: Defines how the plant is expected to operate at each of the nodes (i.e., to supply X amount of Y to pump Z, etc.).

PARAMETER: The operational objective, design basis, or physical characteristic of the node (flow, pressure, temperature, level, and in some cases, vacuum). By using simple guidewords such as NO, MORE, LESS, and by asking questions of the intent with the

guideword and parameter (such as NO FLOW), a team can determine all types of credible causes in the node.

CAUSES: Events or failures that result in deviation from design intent for a process parameter. "NO FLOW" for a pump that is blocked in is a credible cause. After the causes are identified, the consequences will be determined.

CONSEQUENCES: A description of the hazard or operability problem that would result from the cause, if subsequent events were to cascade unabated (i.e., trying to start a pump after maintenance without blocking).

SAFEGUARD: Must be proven before they can be listed as a safeguard. Relief valves must flow enough volume as to adequately drop the pressure in all scenarios before it is safe.

4.2 KNO PLANTS 4, 5 AND 6 HAZOP STUDY AND PROCESS HAZARDS ANALYSIS REVALIDATIONS DATA

Copies of Agrium's KNO Plants 4, 5 and 6 original system HAZOP (hard copy) is available on request.

Copies of Process Hazard Analysis ("PAH") Revalidation documentation including the final reports and recommendations are also available on request. PAH revalidations are required every 5 years after the original HAZOP study.

Selected data from the KNO Plants 4,5 and 6 PAH Revalidation files are attached in the Appendix including:

1. PAH Revalidation Goals for KNO Plants 4,5 and 6
2. PAH Revalidation Philosophy for KNO Plants 4, 5 and 6
3. PAH Revalidation Schedules for Plants 4,5 and 6
4. Complete PAH Revalidation checklist for Plants 4, 5 and 6
5. PAH Revalidation system numbers for Plants 4, 5 and 6
6. Final Reports, Summary Memos and wrap-up check-list for KNO Plant 4
7. Final Reports, Summary Memos and wrap-up check-list for KNO Plant 5
8. Final Reports, Summary Memos and wrap-up check-list for KNO Plant 6

4.3 PROJECT QUANTITATIVE RISK ASSESSMENT

Extensive quantitative risk assessments have been performed for ammonia and urea plants which have been applied to the site-specific situation of this Project. The quantitative risk assessment focuses on potentially hazardous releases which could pose risks to the workers within the battery-limit of the plant and the community outside the battery-limits.

Hazard/failure Scenarios

HAZOP studies on the KNO ammonia urea plant (and as such this Project) focuses on toxic hazards (ammonia) and flammable hazards (feedstock methane or synthesis gas).

The failure cases are usually classified into small leaks (3 to 5mm), medium leaks (60 to 100mm) or rupture conditions. Usually EIA for ammonia urea projects under developments rely on theoretical modeling to simulate operating conditions. The advantage with this Project is that KNO plant characteristics is well defined by several years of operation with full HAZOP studies clearly underlining the quantitative risk analysis.

Frequency and Consequence Analysis

Frequency analysis of historic ammonia urea plant operating data indicate that 36% of leaks usually emanate from equipment containing methane and hydrogen (flammable hazard) with accidental leaks expected to occur every 1.6 years, on average.

The balance 74% of releases are ammonia majority (circa 60%) expected to occur in the urea plant – the rest occurs at the ammonia tank and the ammonia loading equipment. The risk of leakage from the ammonia tank and the ammonia loading equipment are statistically low but can have severe consequences.

This Project does not plan to produce ammonia for sale which eliminates this element of risk.

In essence the risk of large methane and hydrogen releases and large ammonia releases from the ammonia tank are considered to be the most critical from the occupational and community health and safety perspectives.

The KNO ammonia tank will not be relocated. Instead the construction of a new 10,000 MT double-wall ammonia tank is included in the Project EPC scope. In addition the natural gas feedstock intake facilities will be new. These facilities will be designed, fabricated and installed to meet best-in-class safety standards and operating practice.

Impact Analysis

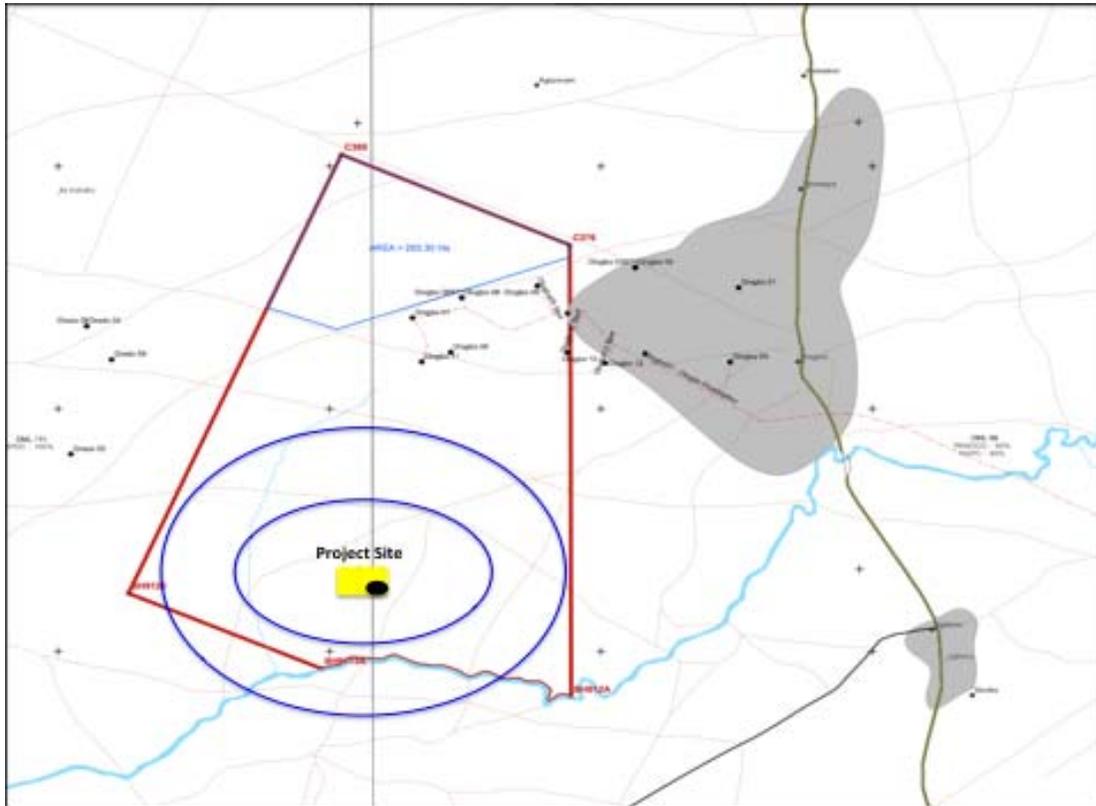
The typical risk levels associated with ammonia tanks are as follows:

- *0.005/ average year at the tank area*
- *0.001/average year approx 200 meters from the tank*
- *0.0005/average year approx 300 meters from the tank*
- *0.0001/average year approx 400 meters from the tank*
- *5E-005/average year approx 550 meters from the tank*
- *1E-005/average year approx 600 meters from the tank*
- *5E-006/average year approx 750 meters from the tank*
- *1E-006average year approx 900 meters from the tank*
- *1E-007/average year approx 1,200 meters from the tank*

The 1.5 KM and 2.0 KM contours around the Project site are shown in Figure 4.1. The Ossimo site is marked in red and the current areas of inhabitation shown in grey. Clearly, the potential affected zone is well away from the community and within the Ossimo

industrial park area.

Figure 4.1 Showing 1.5 KM and 2.0 KM around the Project Site – the Ossiomo Industrial park is marked in Red and significant inhabitation is marked shown in Grey



In the event of an

accidental release of ammonia from the plant the smell of ammonia may cause concern amongst the public. As the range in which the odour of ammonia can be detected covers concentration down to 25 PPM, releases of ammonia could potentially be detected up to 5 KM away from the source depending on the concentration – there is currently no significant inhabitation within 5 KM of the Project site.

Nevertheless comprehensive procedures will be put in place to manage any potential occupational and community health and safety impacts.

The KNO plant was designed and operated with the highest level of safety in the industry. The relocated plant will continue these safety features and practices. In addition a number of safety features and procedures will be introduced during the relocation to enhance the safety features of the plant. These include:

- The analogue control system in the KNO plant will be replaced by a new digital control system
- Ammonia plant flare will be relocated to the new site
- Ammonia detectors and early leak detection warning systems
- KNO HAZOP study provides critical background for the design, erection and operation

- of the new plant
- Build on KNO plant operating experience

4.4 FIRE FIGHTING

Spontaneous combustion of flammable gases, fires and explosions are a major risk hazard in petrochemical plants. The HAZOP study evaluates the fire and explosion risk associated with the operation and maintenance of the KNO plant and the historic operating experience will be extended to this Project.

The scope of work of the EPC includes the design and installation of fire fighting facilities including a new fire station building, fire trucks, plant wide fire fighting systems, firewater storage and pumping, a ring main and firewater loop grid, sprinkler systems, dry gas system, fire trucks and fireproofing of all relevant equipment. The fire fighting station is designed to be independent and fully capable of putting out any major fires such as a fire generated from the rupture of the ammonia tank.

In particular:

- Fire alarms will be provided throughout the plant and in particular, in the fire station and the operation control room
- Point smoke detectors will be provided throughout the plant and in particular, at the power distribution room and the transformer room
- cable-type linear model heat detectors will be provided in the interlayer of the power cable
- manual alarm buttons and voice and light alarms will be provided on each floor plane in the production Plant building
- the low-pressure fire water pipes and industrial water pipes are integrated and they installed in loop form in the unit area
- fire hydrants will be installed in all buildings conforming to the relevant national building codes
- the fire hydrants will be mounted on the fire water pipes with spacing of less than 120m
- steel pipes will be used as material selection for the loop fire water system
- high-pressure fire water system will be installed with water supply capacity of 10m³/h and water supply pressure of 1.0MPa
- Three high-pressure fire pumps will be installed, two pumps in use and one pump for backup, with each pump flow of 360m³/h and lift of 1.0MPa
- Two pressure maintaining fire pumps will be installed, one in use and one for backup, with each pump flow of 15m³/h and lift of 1.0 MPa.