HUMANITIS: Jurnal Humaniora, Sosial dan Bisnis
Vol. 3 No. 6 Juni 2025, hal. 1547-1557 e-ISSN: 2988-6287

HAZARD EXAMINATION OF AMMONIA UNIT CONVERTER IN FERTILIZER INDUSTRY UTILIZING HAZOP STRATEGY

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Abstract
Hazard Framework, Hazard Administration, HAZOP, Ammonia Converter, Hazard Examination, Ammonia Plant This ponder assesses the security and operational dangers of the smelling salts converter unit in an smelling salts generation plant utilizing the Danger and Operability Consider (HAZOP) technique. The investigation recognized a few potential dangers, counting moo weight within the converter due to limited channel stream, tall temperature at the gas burner coming about from broken tubes, and moo temperature during the change prepare that will diminish ammonia transformation productivity. Extra issues were watched in supporting units, such as overpressure within the compressor and no stream within the refrigeration framework. These deviations might lead to decreased item surrender, catalyst wastefulness, hardware disappointment, or indeed major security episodes. The think about suggests remedial activities such as controlling gulf stream rates, executing interlock frameworks, conducting schedule reviews, and moving forward temperature and stream observing. These discoveries offer profitable experiences into moving forward the unwavering quality, security, and proficiency of ammonia converter operations and give a organized system for risk moderation in comparative high-risk chemical forms.
Keywords *Risk Matrix, Risk Management, HAZOP, Ammonia Converter, Risk Analysis, Ammonia Plant.*

INTRODUCTION

The fertilizer industry is crucial for national food security, particularly in agrarian countries like Indonesia. Ammonia (NH_3) is the most crude fabric for nitrogen fertilizer, delivered through complex chemical forms. This process poses high risks to occupational safety, the environment, and industrial assets. To guarantee security and proficiency, efficient endeavors are required to recognize and assess potential risks in ammonia generation frameworks. One of Indonesia's largest fertilizer companies has modern ammonia factory facilities. The ammonia converter, a reactor where nitrogen and hydrogen gas synthesis occurs, is a crucial part of the ammonia production process. Appropriate administration of this reactor is basic to avoid disappointment. A common method for hazard evaluation within the handle industry is the Risk and Operability Ponder (HAZOP), which distinguishes potential risks and operational deviations from the arranged framework design.(1,2) HAZOP is a method where a multidisciplinary team uses a keyword guide to review each process system, identifying deviations and their impact on safety and reliability, thereby detecting hidden risks and offering mitigation recommendations (3).

In this investigate, we performed a chance evaluation utilizing a HAZOP strategy, concentrating on the smelling salts converter unit at one of Indonesia's biggest fertilizer producers. This particular unit was selected due to the critical nature of its operations and its sensitivity to variations in operating conditions, where even minor errors can result in significant repercussions. The analysis involved gathering technical data, modeling the process system, and engaging in discussions with the technical team knowledgeable about the operational characteristics of the ammonia conversion unit.

The ammonia converter is a vital and sensitive component of the ammonia production process in fertilizer industry, facilitating the synthesis reaction between nitrogen (N_2) and hydrogen (H_2) gases under conditions of high temperature and pressure. This process demands stringent control measures due to the flammable properties of the raw materials and the heightened risk of explosion in the event of a leak or operational anomaly. Besides, the converter works at temperatures extending from 400 to 500°C and weights surpassing 100 atm, which inalienably lifts the probability of hardware disappointments, such as reactor tube breaking, catalyst debasement, or the discharge of perilous substances. Such risks not only jeopardize worker safety and damage equipment but also pose a threat to the surrounding environment through the potential release of toxic and corrosive ammonia gas.

Additionally, ammonia converters play a crucial role in ensuring the sustainability of the entire production process. Any disruption to this unit can lead to a total halt in production, resulting in considerable economic losses. Consequently, it is essential to ensure the presence of safety systems and operational reliability through a systematic and organized approach. In this setting, conducting a hazard appraisal could be a basic preventive degree to distinguish potential dangers, survey their causes and impacts, and create appropriate moderation techniques. (4).

Alongside the technical and operational considerations, the necessity for conducting risk assessments is also influenced by regulatory requirements and industry standards (5,6). The chemical segment, especially in smelling salts generation, must follow to a run of word related and natural security controls. These regulations are enforced by governmental bodies through K3 standards and are also aligned with international benchmarks such as ISO 45001 and IEC 61511, which highlight the significance of process safety management. The application of risk assessment methodologies, such as HAZOP (Hazard and Operability Study), is particularly pertinent as they systematically identify process anomalies using keyword frameworks and incorporate diverse expertise within the assessment team.

Given the various factors involved—including the inherently high-risk nature of the processes, the potential consequences for safety and the environment, and the necessity for regulatory compliance—conducting a risk assessment for an ammonia converter is essential. This strategy not only seeks to reduce the likelihood of accidents but also aims to enhance operational efficiency and ensure the safe and sustainable continuation of production activities. (7).

A few analysts have conducted HAZOP investigation on smelling salts plants. Noriyanti, et al, examined HAZOP in the Fuel Gas Superheat Burner section (8), Musyaffa et al, studied HAZOP in the steam system section (9), Solomon et al, review HAZOP in the Reforming Section (10), Roy et al study HAZOP in ammonia storage (11), Gillespie et al, studyHAZOP di bagian Ammonia Fuel Systems (12).

This study aims to identify possible risks associated with the ammonia converter unit, assess the underlying causes and effects of operational anomalies, and offer recommendations to enhance the system's safety and reliability. The findings are anticipated to bolster the safety culture at one of

Indonesia's largest fertilizer companies and serve as a benchmark for similar industries in their proactive and systematic approaches to risk management.

RESEARCH METHOD

Think about Approach

This think about employments a case consider approach to conduct a prepare chance appraisal on the unit Ammonia converter in one of the smelling salts generation manufacturing plants in Indonesia. The most objective of this think about is to recognize potential dangers, assess dangers, and propose fitting moderation measures utilizing the HAZOP strategy (Danger and Operability Think about).

Consider Protest

The protest of think about is the unit Ammonia converter, which is one of the most components within the process of synthesizing Ammonia from hydrogen (H_2) and nitrogen (N_2) gas with the assistance of an press catalyst at tall weight and temperature. This unit works beneath extraordinary conditions, so it has the potential for noteworthy threat in the event that deviations from ordinary working conditions happen.

Hazard Evaluation Strategy

The HAZOP strategy was chosen because of its viability in distinguishing handle deviations that may cause risks or operational disturbances. HAZOP could be a efficient and team-based subjective strategy (multidisciplinary group), which is done by checking the method through breaking the framework internal hubs and assess each handle parameters utilize direct words certain.

Stages of HAZOP Execution

Execution of HAZOP considers on units smelling salts converter carried out through the taking after stages:

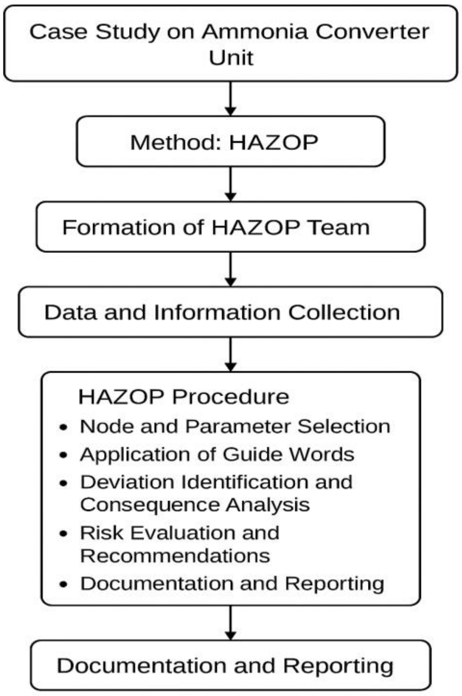


Figure 1. Flowsheet HAZOP in Unit Ammonia converter

1. Arrangement of the HAZOP Group
   The HAZOP Gather comprises of interest staff who have involvement and specialized data of the Ammonia handle, checking:
   - Handle build
   - Field administrator
   - Word related security and wellbeing (K3) master
   - Support design
   - HAZOP Facilitator (as mediator)
2. Information and Data Collection
   Data collected incorporates:
   - Prepare Stream Graph (PFD)
   - Channeling and Instrumented Graph (P&ID)
   - Converter unit commonplace working data (weight, temperature, stream rate)
   - Verifiable occurrence information and near-miss
   - Standard working methods (SOP)

Probability

Severity	Very Unlikely (1)	Unlikely (2)	Possible (3)	Likely (4)	Very Likely (5)
Minor 1)	1 Low	2 Low	3 Moderate	5 High	5 Very High
Moderate 2)	2 Low	4 Moderate	8 Moderate	10 High	10 Very High
Major 3)	3 Low	6 Moderate	12 High	12 High	15 Very High
Serious 4)	4 Low	8 High	15 Very High	20 Very High	20 Very High
	5 Moderate	10 High	15 Very High	20 Very High	25 Very High

Probability

Figure 2. Risk Matrix

3. Hub and Parameter Assurance
   The system is isolated into a number of center based on coherent plan parts, for case:
   - Channel bolster gas
   - Response zone (reactor containing catalyst)
   - Gas outlet (ammonia item) For each center, critical parameters such as: stream rate, weight, temperature, composition and level are decided.
4. Direct Words application
5. Coordinate words like No, More, Less, As well as, Parcel of, Switch, And Other than utilized to survey conceivable deviations from conventional conditions. For outline:
   - "No Stream" to recognize potential blocked stream
   - "Tall Temperature" to survey the danger of overheating
6. Deviation Distinguishing proof and Result Examination
   Any combination of parameters and direct word assessed to recognize potential deviations, conceivable causes, results for security, the environment, and operations, and the require for moderation measures.
7. Hazard Assessment and Suggestions
   Recognized dangers are assessed based on seriousness (seriousness), the likelihood of event (probability), and discovery, employing a basic chance lattice. Moderation activity proposals are defined for unsatisfactory dangers (unsatisfactory hazard).

Documentation and Detailing

All HAZOP examination comes approximately are filed in table outline containing:

- Hub
- Deviation
- Reason
- Affect
- Accessible security
- Hazard level Proposal

RESULT AND DISCUSSION

Process Description

Mechanical Smelling salts era is for the foremost portion carried out through the Haber-Bosch get ready, which combines nitrogen gas (N_2) and hydrogen gas (H_2) in a molar extent of 1:3 to create Ammonia gas (NH_3). This handle takes put underneath tall weight and tall temperature interior a system known as the amalgamation circle, maintained by a refrigeration system that decontaminates and liquefies the noticing salts thing.

Compression and Bolster Planning Arrange

The nourish gas from upstream units (such as the methanator) is to begin with compressed to reach the ideal working weight for the smelling salts converter. This weight is regularly around 150–300 bar, with temperatures around 400–500 °C. Compression is basic for proficient response, as Ammonia arrangement is an exothermic response including a lessening in gas volume, so tall weight shifts the harmony toward the item (smelling salts).

Some time recently entering the reactor, the gas is filtered and dried to evacuate water and other debasements, more often than not through adsorption or condensation frameworks. The clean, dry gas is at that point reinforced into the noticing salts converter or amalgamation reactor.

Response Prepare within the Ammonia Converter

The most response happening within the converter is:

N2+3H2 $\longrightarrow$ 2NH3+Energy

This response is exothermic (discharges warm) and is encouraged by an iron-based catalyst (Fe), frequently advanced with metal oxides such as K_2O, Al_2O_3, or CaO to improve catalytic action and steadiness. In spite of the fact that the response is thermodynamically favorable at moo temperatures and tall weight, a compromise in temperature is required since the response rate is as well moderate at low temperatures. Consequently, the working temperature is chosen to accomplish a sensible change rate interior an commendable reaction time.

Synthesis Loop

Within the loop system, nitrogen and hydrogen gases are continuously fed into the process. Since only a small portion of the gas (approximately 15–20%) is converted into ammonia in a single pass through the reactor, the unreacted gases are recycled. These gasses are recompressed and reintroduced into the reactor to progress generally handle proficiency. The loop also includes a system to separate ammonia from the gas mixture after it exits the reactor. This is achieved by cooling the gas mixture until the ammonia condenses into liquid form, while the nitrogen and hydrogen remain in a gaseous state.

Ammonia Refrigerant Framework

After the reaction, the gas mix containing Ammonia is cooled utilizing an Ammonia refrigeration system, which livelihoods liquid Ammonia as the refrigerant. The blend is cooled down to roughly -33 °C, which is the condensation point of smelling salts at climatic weight. The condensed fluid Ammonia is isolated and collected as the ultimate item. The uncondensed gasses (by and large N_2 and H_2) are at that point recompressed and returned to the mix circle as reused support, growing capability and minimizing gas waste. The block ammonia production can be seen in the Figure 3.

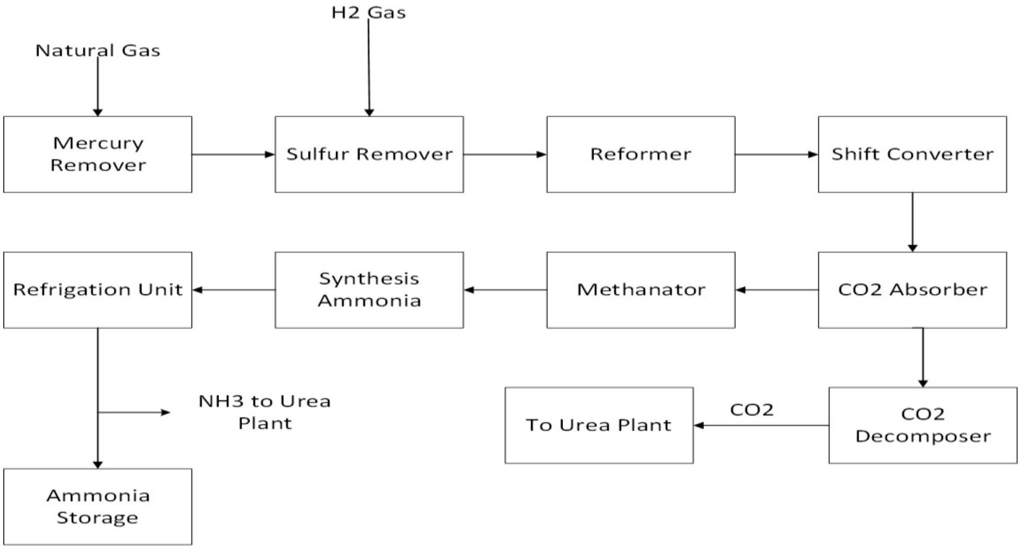
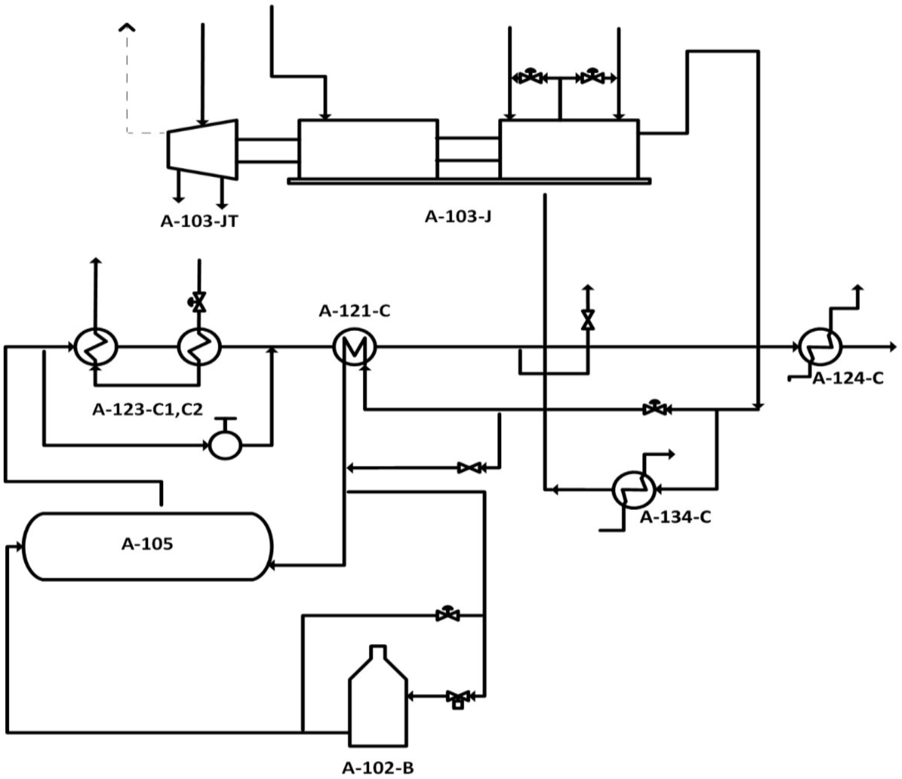


Figure 3. Block Diagram Of Ammonia Production

The ammonia production process begins with natural gas and hydrogen gas as the primary feedstocks. The natural gas first undergoes mercury removal to eliminate mercury impurities that could damage downstream catalysts. It at that point enters a sulfur evacuation unit, where sulfur compounds are extricated to anticipate catalyst harming amid the changing organize. In the reforming unit, hydrocarbons in the gas react with steam to produce a mixture of hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2). The coming about gas is then prepared in a move converter, where CO responds with water to produce extra hydrogen and CO_2. The CO_2 is retained in a CO_2 safeguard and in this way isolated in a CO_2 stripper, where it is recouped and sent to the urea plant. Any remaining follows of CO and CO_2 are changed over into methane within the methanator to anticipate impedances within the ammonia blend reaction. The purified gas stream, rich in hydrogen and nitrogen, is then compressed and fed into the ammonia synthesis reactor, where the gases react under high pressure and temperature in the nearness of a catalyst to make ammonia (NH_3). The coming about ammonia is condensed and isolated from unreacted gasses through a refrigeration process. Finally, the liquid ammonia is stored in dedicated storage tanks and a portion is directed to the urea plant for further processing into urea fertilizer.

HAZOP Analysis

To identify potential hazards in the operation of the ammonia converter unit and its supporting equipment, a Hazard and Operability Study (HAZOP) was conducted. This strategy methodicallly analyzes conceivable deviations from normal operating conditions that will lead to security dangers, natural impacts, or disturbances within the handle. The examination centered on key prepare parameters such as weight, temperature, and stream over a few basic units counting the smelling salts converter, gas burner, compressor, and refrigeration framework. The taking after table (3.1) summarizes the HAZOP comes about, highlighting the causes and results of deviations, existing shields, and suggested activities to moderate the related dangers. The following can be seen in the Figure 4, related to ammonia converter process flow diagram.



No	Equipment Code	Equipment Name
1	A-102-B	Gas Burner
2	A-103-JT	Compressor
3	A-103-J	Compressor
4	A-105	Ammonia Converter
5	A-121-C	Heat Exchanger
6	A-123-C1	Heat Exchanger
7	A-123-C2	Heat Exchanger
8	A-124-C	Heat Exchanger
9	A-134-C	Heat Exchanger

Figure 4. Ammonia Converter Process Flow Diagram

Table 1. HAZOP Analysis

No	Location/ Operating Unit	Parameter	Guide word	Deviation	Causes	Consequence	Safeguard	L	C	R	Recommendation
1	**Ammonia Converter**	Pressure	Less	Low Pressure	Pressure drop inlet and outlet in ammonia converter too high (PDI1054)	The production rate decreases and the catalyst in the ammonia converter does not work properly, and the reaction that occurs is not 100% in 122-C	Reduce the inlet rate to the ammonia converter and reduce the pressure on the ammonia converter. (reduce flow in FE 1105)	1	4	4	- Add automatic control to maintain pressure balance at inlet and outlet. - Regularly inspect control valve FE-1105. - Perform routine checks on PDI1054.
2	**Ammonia Converter A-105**	Temperature	Less	Low Temperature	temperature on A-102-Bis low	temperature in A-105 is lower than 250 deg C	increase the A-102-B gas inlet flow rate	1	4	4	- Optimize the flow rate of gas entering A-102-B through automatic monitoring. - Periodically inspect and maintain A-102-B heater performance.

3	**Ammonia converter (A-105)**	Temperature	Less	Low Temperature	The temperature on the ammonia converter is too low	The reaction in 122-C that occurred was less than 100%	turn on A-102-B while the reaction is taking place (not just for start up)	1	3	3	- Operate A-102-B continuously during the reaction, not just during startup. - Add interlock system to ensure A-102-B remains active during operation.
4	**Compressor (A-103-J)**	Pressure	More	High pressure	Overpressure	leaks in pipes or at pipe joint welds	Installing control valve	2	3	6	- Install a pressure relief valve (PRV) as an additional safety measure. - Perform regular leak testing on pipe joints and welds
5	**Gas burner (A-102-B)**	Temperature	More	High Temperature	Over Temperature in A-102-B	Tube on burner broken	Installing system interlocks (FT-1257B)	2	5	10	- Install an automatic high-temperature trip system. - Schedule regular thermographic inspections to detect abnormal hot spots.
6	**Refrigerant (A-123-C1,C2)**	Flow	No flow	No Flow	no flow entering one of the cooling units because the tube is broken	no flow rate entering the cooling unit	the ammonia converter outlet (H140) is closed	1	5	5	- Install flow sensors and alarms to detect flow loss early. - Conduct routine inspections of cooling tube integrity and valve operation.

Based on the HAZOP analysis results presented in the table, it is evident that most of the potential hazards stem from uncontrolled deviations in process parameters, such as low pressure in the converter, high temperatures in the gas burner, and lack of flow in the cooling system. These deviations can lead to reduced ammonia conversion efficiency, equipment failure, and major operational disturbances. Suggested relief measures incorporate altering gulf stream rates, introducing interlock frameworks for temperature control, and conducting normal assessments on pipeline joints. The execution of these proposals is expected to improve chance administration, progress security, and guarantee more solid and productive operation of the ammonia converter unit.

CONCLUSION

Based on the risk analysis using the HAZOP method on the ammonia converter unit, the following conclusions can be drawn:

1. The main potential hazards identified in the ammonia production facility include overpressure, extreme temperature deviations (either too high or too low), flow failure, and off-spec product composition. These hazards are particularly evident in units such as the ammonia converter, gas burner, compressor, and refrigerant system.
2. The causes of these deviations include failures in control equipment (blockages in pipelines, tube ruptures, poor joint welds, and malfunctions in the gas separation and cooling systems. For example, high pressure in compressors and low temperatures in the ammonia converter have been linked to system inefficiencies and material fatigue.
3. The consequences of these deviations are potentially severe, ranging from reduced production efficiency and catalyst deactivation to equipment damage, explosion risks, and total shutdown of

the process. Low temperatures in the converter, for instance, can result in incomplete reactions, affecting overall product quality.

4. Existing shields incorporate programmed shutdown frameworks, temperature and weight observing sensors, stream cautions, weight security valves, interlocks for burner security, and weld reviews in high-pressure ranges.
5. The hazard level for most distinguished deviations is categorized as medium to tall. Subsequently, a few relief activities are prescribed, counting:
   - Schedule support and assessment of security valves, control frameworks, and burner hardware
   - Intermittent calibration of weight and temperature sensors
   - Establishment reinforcement frameworks for pumps and burners
   - Changes within the proficiency of the adsorption and cooling frameworks to preserve steady operation and item details
   - Strengthening of mechanical integrity through weld testing and proper material selection in high-stress area.
6. The usage of these moderation activities will upgrade operational unwavering quality, diminish mischance dangers, and guarantee handle coherence. This HAZOP-based approach contributes altogether to progressing handle security within the smelling salts converter unit and underpins compliance with industry guidelines and word related security controls.
7. Office can be essentially improved through this HAZOP-based approach. The process safety of the ammonia converter unit can be greatly improved in alignment with industry standards and applicable occupational safety regulations.

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