PETROLEUMSTILSYNET

Investigation report

Report	
Report title Investigation – work accident with ammonia exposure – Naturkraft	Activity number 032000001

Security grading

☑ Public	☐ Restricted	☐ Strictly confidential
☐ Not publicly available	☐ Confidential	

Summary

During work to replace a valve on the filling line to ammonia tank 2, ammonia solution (ammonium hydroxide) began to spurt out when the flange was broken.

One person suffered corrosive injuries to their skin and eyes, and another breathed in ammonia vapour while suffering minor bruising to their arms and feet.

Involved	
Main group T-L	Approved by/date Kjell Arild Anfinsen/15 August 2013
Members of the investigation team Hilde Nilsen, Sissel Bukkholm	Investigation leader Arne Johan Thorsen

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1 Summary

A leak of ammonia solution (ammonium hydroxide) occurred on 30 May 2013 during maintenance in Naturkraft's gas-fired power station at Kårstø. The Petroleum Safety Authority Norway (PSA) resolved on 3 June 2013 to conduct its own investigation of this incident.

During work to replace a valve on the filling line to ammonia tank 2, ammonia solution began to spurt out when the flange was broken.

The direct cause of this leak was that the tank had an overpressure of 0.25 bar. Since the filling line descended some distance into the liquid in the tank, the pressure acted on the liquid so that ammonia solution ascended through the piping and emerged from the flange when this was broken.

Actual consequences
One person suffered corrosive injuries to their skin and eyes.
One person breathed in ammonia vapour and suffered minor bruising to their arms and feet.

Potential consequences
The outcome of the incident could have been more serious for both people.

Observations
Three nonconformities from the regulations were observed:

- inadequate risk understanding and assessment
- inadequate education
- insufficient water/water pressure in the emergency shower.

and one improvement point:

- inadequate training and exercises.

2 Introduction

A leak of ammonia solution (ammonium hydroxide) occurred on 30 May 2013 during maintenance in Naturkraft's gas-fired power station at Kårstø. The PSA resolved on 3 June 2013 to conduct its own investigation of this incident.

Composition of the investigation team
Arne J Thorsen, investigation leader
Hilde Nilsen
Sissel Bukkholm

Procedure
The investigation team went to Kårstø on 5 June 2013.

Naturkraft initially presented a brief review of the incident, followed by a site inspection. The team conducted a number of interviews at Naturkraft and at Haugesund Hospital, and went through governing documents.

The investigation team returned to Stavanger on 7 June 2013.

Mandate

1. Clarify the scope and course of the incident.
    a. Identify and assess safety and emergency preparedness aspects.
2. Describe the actual and potential consequences.
    a. Harm caused to people, material assets and the environment.
    b. Assess the potential of the incident for harming people, material assets and the environment.
3. Identify and describe observations of direct and underlying consequences.
    a. Observed nonconformities from requirements, approaches and procedures.
    b. Improvement points.
4. Discuss and describe possible uncertainties/ambiguities.
5. Identify possible breaches of regulations, recommend further follow-up and propose measures to be applied.
6. Prepare a report and accompanying letter in accordance with templates.

Establish a timetable for implementing the work.

3 Course of events

Naturkraft's gas-fired power station was not in operation when the incident occurred.

A three-inch filling valve on top of an ammonia tank was leaking and required replacement. The system is normally depressurised, but a small overpressure can build up. A work order was established on 28 May 2013, with execution planned for 3 June 2013. An application was submitted for a level 1 work permit (WP) to be executed on the planned date. A level 1 WP is required for high-risk work, including work with hazardous chemicals. Because one of the people originally intended to do the job was off sick, it was decided to postpone execution until 30 May 2013. The workers and the shift supervisor had a pre-job discussion before the work started.

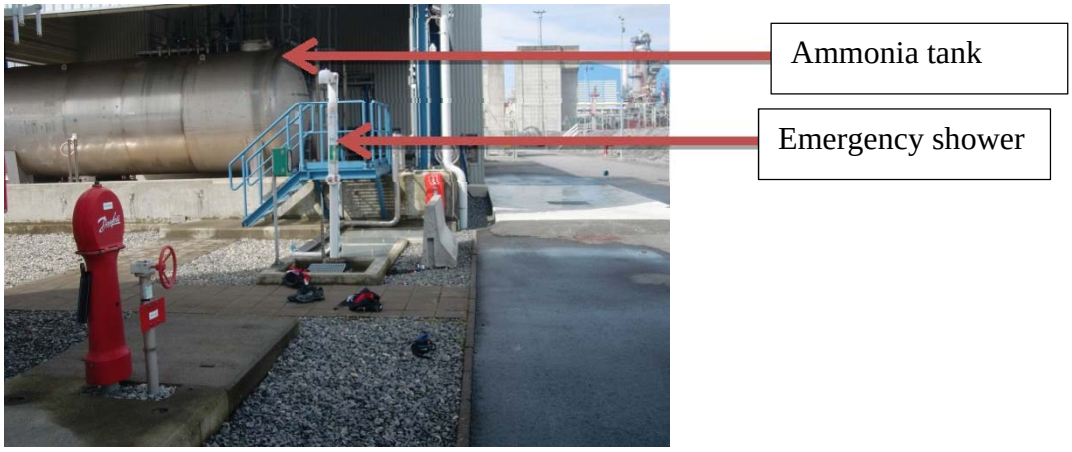
Two tanks are installed for 25 per cent ammonia solution, each of 50cu.m. The tank to be worked on was about 45 per cent full.

The job was to be done by two people. One was to act as safety guard, since the work would be done outside the railings on the landing between the ammonia tanks, and safety harness would be worn. The WP prescribes the use of gastight goggles and gas masks during the work. That applied to the person replacing the valve, but not to the safety guard.

Removing the actuator and opening the valve manually to drain ammonia solution from the pipe to the tank were the initial steps. Work continued once the team heard the draindown cease. They discovered that the bolts on the valve had not been fully tightened. Tightening these did not stop the leak, and it was decided to replace the valve. The safety guard continued to ready equipment and tools up on the landing, while the other person went out onto the tank and started disassembly. As soon as the bolts had been loosened, ammonia solution began to spurt out between the valve and the pipe flange. The person working on disassembly out on the tank stood up and turned away from the chemical spray, which was so powerful that his whole body became covered. Ammonia solution penetrated behind his goggles and beneath his gas mask, and he accordingly tore these off. He managed to get over the railings, out of the safety harness, across to the ladder and down from the landing. On reaching the emergency shower, he began to remove his clothes. The emergency shower quickly lost water pressure, and the person ran to the office building and the changing room shower. At the same time, he notified the ammonia leak. This had already been detected by the line detectors at the edge of the area. The point detectors over the tanks had been overridden, so they sounded an alarm in the control room but initiated no action in the plant.

The safety guard was standing on the landing when the leak began. He saw the person on the tank being sprayed, but was unable to help him. He wore nothing to protect against ammonia. After breathing in ammonia vapour, he escaped from the location by jumping down from the tank via a cable tray. The height was about four metres. He escaped from the gas cloud and tried to raise the alarm via PA, but his message was not understood by the control room.

When the alarm sounded, the person who had worked on the valve came running in and reported where the accident had happened. Two people then ran out to assist the safety guard. Their search for him took them partly through the gas cloud. They found the guard quickly behind the tank building and helped him to the changing room.



Statoil's health and safety personnel at Kårstø were quickly on the scene with fire appliances and ambulances. Some confusion arose over the location of the second person, and a search was planned down towards the sea. But the missing person turned up before any action could be taken. The two injured people were assisted by the health and safety team. The person in the shower was eventually taken up to the fire station because of inadequate water pressure in the changing room shower.

The health and safety team quickly began spraying water on the ammonia tank, and this continued until the leak ceased..

Both the injured people were transported after about an hour to Haugesund Hospital, where they received further treatment. The safety guard who had breathed in ammonia vapour was discharged later that evening. His colleague received treatment for corrosive injuries to the eyes and skin, and remained in hospital for more than a week.

4 Potential of the incident

Actual consequences

One person was covered by the ammonia spray and suffered corrosive injuries to skin and eyes. According to him, a week of hospital treatment had fully restored his right eye, while the left was 80 per cent recovered with good prospects for full restitution. The damage to his skin was less serious and largely healed after a week. He had suffered no identifiable injury from breathing in ammonia vapour. He was on sick leave for 17 days.

One person breathed in ammonia vapour. He suffered minor bruising to arms and feet when jumping down from the tank. He was discharged from hospital later the same evening, and spent eight days on sick leave.

Material damage was insignificant and, since the power station is currently not in operation, no losses were incurred from a shutdown.

We have not found that any damage was caused to the environment, since all the ammonia solution was contained by the collection system.

Potential consequences
The person sprayed with ammonia solution wore a safety harness during the work. Had he failed to remove this, or fallen and remained hanging from it, his corrosive injuries could have been much more serious. He would probably have suffered serious damage to his eyes, and the corrosive damage to his skin might have been more extensive. Breathing large volumes of ammonia vapour could also have caused internal corrosive injuries and, in the worst case, death. Had larger amounts of ammonia solution got into his eyes, he might have fallen and hurt himself on his way down from the tank or to the emergency shower.

The second person jumped down from the tank to a concrete floor, a distance of about four metres. Falling onto the concrete could easily have caused more extensive personal injuries. Breathing in the vapour could have irritated the respiratory system.

We do not expect that the incident would have harmed the environment or caused extensive material damage.

5 Observations

The PSA's observations fall generally into three categories:
- nonconformities: observations where the PSA believes that regulations have been breached
- improvement points: observations where deficiencies are found, but insufficient information is available to be able to establish a breach of the regulations
- conformities/barriers which have functioned: used where conformity with the regulations has been established.

Nonconformity no 1: inadequate risk understanding and assessment

Description
Risk understanding and risk assessments of the facility were inadequate.

Grounds
- It was not certain that the company had an adequate overview of risks in the facility. The risk analysis for the facility could not be provided to the investigation team.
- Important risk contributors were not identified before planning, organising and executing the work.
- Specific risk assessments had not been conducted for various jobs on the ammonia system, even though the hazards posed by this chemical were known.
- WP procedure D&V-DFT-01 requires a safe job analysis (SJA) to be considered. This job was regarded as routine (the simple replacement of a valve) on a straightforward system, and no SJA was therefore carried out.

Requirements
Section 10 of the framework regulations on prudent activities
Section 6 of the management regulations on health, safety and the environment
Section 17 of the management regulations on risk analyses

Nonconformity no 2: inadequate education

Description
It was not certain that personnel had sufficient education to be able to carry out the relevant activity in a safe manner.

Grounds
- It emerged from interviews that employees had not been adequately educated about the ammonia system.
- Workers had not been given sufficient education on hazardous chemicals. Teaching is provided via a web-based system, but this is a general education in the use of safety data sheets.
- It emerged from interviews that the workers are not systematically informed about updates to safety data sheets.

Requirements
Section 50 of the technical and operational regulations on competence
Section 3-1 of the regulations relating to conduct of work concerning education on working with hazardous chemicals (in Norwegian only)

Nonconformity no 3: insufficient water supply/pressure in the emergency shower

Description
The water supply in the emergency shower used in the incident had limited pressure and ceased to function.

Grounds
- It emerged from interviews that the water supply to the emergency shower failed and the injured person had to run to the office building and use the changing room shower.

Requirements
Section 67 of the technical and operational regulations on handling hazard and accident situations

Improvement point no 1: inadequate training and exercises

Description
A number of employees had not participated in emergency response exercises at the facility.

Grounds
- The emergency preparedness plan incorporates a general point on chemical discharges, but ammonia is not mentioned.
- Two people ran through ammonia vapour without protective gear at an early stage in the incident while seeking to assist one of those injured. This does not accord with the description in the emergency preparedness plan.

- It emerged from interviews that a number of employees had not participated in emergency response exercises at the facility. Some had taken part in such exercises a number of years ago.

Requirements
Section 52 of the technical and operational regulations on practice and exercises
Section 3-15 of the regulations relating to conduct of work concerning emergency preparedness plans for work with chemicals (in Norwegian only)

Barriers which have functioned

Statoil's emergency response team from Kårstø was on the scene quickly. The medical first aid given helped to reduce personal injuries.

6 Discussion

The direct cause of this leak was that the tank had an overpressure of 0.25 bar. Since the filling line descended some distance into the liquid in the tank, the pressure acted on the liquid so that ammonia solution ascended through the piping and emerged from the flange when this was broken.

The personnel were not aware of any simple method for bleeding off pressure in the tank. Flanges can be broken and bleed points opened. That calls for access and would not bleed off to a secure area.

No calculations have been made of the volume which escaped, and the initial estimate was that this could amount to as much as 1 000l. Naturkraft has later calculated that the total was about 100l, based on level measurements recorded for the tank

General observations on the working environment at the facility
Several conditions at the facility described in interviews indicate challenges with systematic follow-up of the working environment. These factors included high personnel turnover, challenges in getting the safety delegate and working environment committee (AMU) structure to function, operating conditions when the facility is off line, lack of training, communication and worker participation, and rising sickness absence. Such conditions can have a negative effect on the psychosocial working environment, but we have not followed that up in this investigation.

Conditions of this kind can also affect concentration during work, but our investigation has not identified obvious connections between the working environment and the incident.

7 Appendices

A: The investigation has drawn on the following documents:

- Work permit no PE012278
- Work order AO130528.0004
- P&ID NH4OH storage, NOR140-XG02-HSJ-445501, rev 00
- Work permit procedure D&V-DFT-01, rev. 8.00
- Safety data sheet, abbreviated version, 25% ammonia solution, issued 7 December 2011
- Risk assessment 25% ammonia solution, change date 23 May 2012, printed from the substance file
- Safety data sheet 25% ammonia solution, issued 9 November 2012
- Overview of nonconformities/incidents/improvement proposals related to ammonia

B: Overview of people who have participated

C: Abbreviations

- Framework regulations – regulations relating to health, safety and the environment in the petroleum activities and at certain onshore facilities
- Management regulations – regulations relating to management and the duty to provide information in the petroleum activities and at certain onshore facilities
- Technical and operational regulations – regulations relating to technical and operational matters at onshore facilities in the petroleum activities, etc
- Regulations relating to conduct of work – regulations relating to conduct of work, use of work equipment and appurtenant technical requirements
- P&ID – piping and instrument diagram
- SJA – safe job analysis

D: Diagrams/figures/photographs.

- P&ID NH4OH storage, NOR140-XG02-HSJ-445501, rev 00