VOTOB Curriculum for personnel at ammonia terminals

Antea Group

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Introduction

To meet climate targets, the Netherlands and Europe are looking for climate-neutral fuel options. Exclusively generating green energy in the Netherlands, such as wind and solar power, for example, is nowhere near enough to meet the country's and its European hinterland's energy needs.

Green hydrogen could therefore be imported from countries with many natural energy sources (such as wind and solar power in the Middle East and Africa, Canada, the United States, Latin America and Australia). Green hydrogen is considered a suitable and emission-free energy source, which can also make various chemical processes sustainable. However, transporting hydrogen over long distances is very costly and risky, given that it has to be transported at very low temperatures.

Deploying a hydrogen carrier can mitigate these risks. Ammonia is an efficient hydrogen carrier and there is extensive experience with its transport and storage. As a result, preparations for the transport and storage of ammonia as a hydrogen carrier are increasingly being made throughout the world. Terminals in Dutch port areas are making similar preparations.

The toxic properties of ammonia, as well as the Dutch government's risk perception of the storage and transhipment of ammonia, make ammonia terminals (and the transport of ammonia) substantially different from the oil terminals we are familiar with in the Netherlands. When ammonia cracking to produce hydrogen is performed at a terminal, this means that there now is a chemical process plant as well at the terminal. This entails specific knowledge and safety requirements. Operating an ammonia terminal requires specialist knowledge, strict adherence to regulations and procedures, and an organisational culture in which safety is paramount. In short:

> *'You don't just add an ammonia handling facility as an afterthought; it's something you must specialise in!'*
> *André Meulmeester, former Terminal Manager OCI Terminal Europoort*

Purpose of this curriculum

The sector association of Dutch tank storage companies VOTOB and its members are aware of the major importance of having well-trained, safety-conscious people from top to bottom in an ammonia terminal's organisational structure. Members want to take their responsibility in this respect. This curriculum aims to give personnel working at Dutch terminals the knowledge and insights needed to implement safe process management practices in the storage and transshipment of ammonia. This enables both existing and new parties entering the ammonia market to possess the requisite level of knowledge from day one and to act accordingly. It is an industry standard for ammonia terminal operations and is published as such on VOTOB's website.

This curriculum was prepared using the expertise of the PGS 12 Consultation Group and the expertise available at the Antea Group, supplemented by information from interviews with Dutch terminal managers who already have experience with ammonia or who are currently preparing to start working with ammonia.
The interviews covered a wide range of topics, including technical considerations, best practices, ship and train safety assessments, preparing staff to work with toxic substances, characteristics of a safe work culture and the (legal) responsibilities of the terminal manager. In addition, desk research was conducted for some topics. This approach sought to produce the most useful document possible based on practical experience.

This document does not impose any additional obligations on terminals in the sector, but simply expands on existing ones. New VOTOB members are expected to take note of and conform to the contents of this document.

Structure of this curriculum

This curriculum is based on the premise that safety risks can be controlled through means of technical, organisational and people-oriented measures. When these measures are effectively balanced this produces an optimal safety level. Figure 0.1 illustrates this approach.

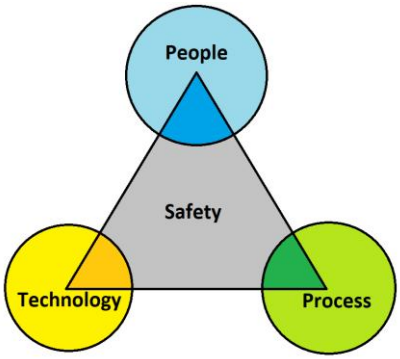

Figure 0.1 Safety is ensured through means of technical, organisational and people-oriented measures that are in balance.

Chapter 1 starts off the curriculum with a brief description of the frameworks within which an ammonia terminal in the Netherlands has to operate: laws and regulations, policy, the ammonia supply chain and the frameworks within which the organisation itself or customers operate.[1].

Chapter 2 contains a description of the processes and installations at an ammonia terminal.

Chapter 3 covers the management and organisation of an ammonia terminal. The core competences of a terminal's management team are described and the safety management system is dealt with.

Chapter 4 shares insights on how to create a safe organisational culture. It includes suggestions from terminal managers on how to work towards an excellent safety culture.

Staff-related issues are discussed in **Chapter 5**, including key areas pertaining to human resource policy, and staff training and education.

Last but not least, **Chapter 6** discusses how to deal with stakeholders in the vicinity of the terminal, such as businesses, the local community, government organisations and emergency services.

Finally, **Chapter 7** provides recommendations for the sector for responsible and safe (ammonia) terminal management.

[1] The document, VOTOB Safety standards in the ammonia supply chain, contains a comprehensive description of the ammonia supply chain from the green ammonia's point of origin to its transport to the Netherlands' hinterland.

1. Frameworks

Ammonia is a highly toxic substance and is stored and transported under high pressure or at low temperatures. When ammonia is released, the size of the resulting toxic cloud can range from several tens of metres to several kilometres. A large-scale release could pose serious health risks in nearby inhabited areas. When liquid ammonia enters surface water or sewers and does not (completely) evaporate, the surface water is polluted. Even a small ammonia leak can be life-threatening for terminal staff. This, in a nutshell, is the impact of an incident involving the release of ammonia.

To mitigate the probability of occurrence of any impact as much as possible, an ammonia terminal must operate within risk mitigation frameworks. The most important such frameworks are listed below.

1.1 Dutch laws and regulations

Because of the potentially large impact area of an incident involving ammonia, the current Dutch government favours alternative hydrogen carriers. However, it also argues that these are not available in the short term, while ammonia is readily applicable as an energy carrier. Attention to safety is paramount in this respect. This is secured in Dutch laws and regulations with the following premise as a basic principle: “You either work safely or you don’t work at all”. The fact that terminals in the Netherlands are or will mostly be built near developed areas largely determines the substance of laws and regulations. For activities within the facility itself, for which a terminal manager has primary responsibility, the following Dutch laws, regulations and guidelines are leading:

- An ammonia terminal, like any other terminal that stores hazardous substances above a certain threshold, falls under the SEVESO directive;
- The Environmental Planning Act contains regulations for activities involving hazardous substances, such as determining areas of focus and site-specific risks;
- The PGS 12 guideline was recently revised for ammonia in particular, setting very high standards for the installations of an ammonia terminal.

1.2 Supply chain responsibility

Because of ammonia’s long history within the chemical industry, the storage and transport of ammonia have already reached a high technological level. After arriving in Europe, ammonia can be cracked to produce hydrogen or used directly as an energy source or in chemical processes. The ammonia supply chain therefore will be as follows:

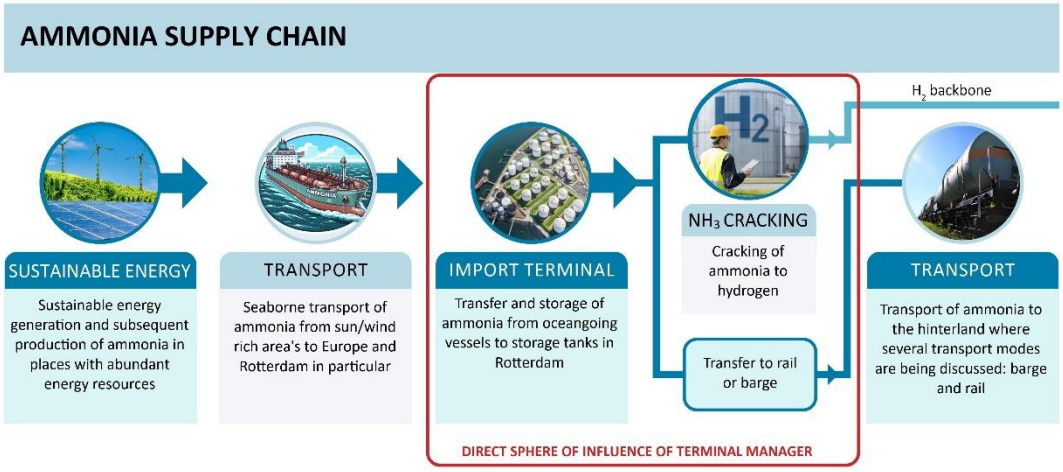

Figure 1.1 The ammonia supply chain

*Transport by road is not included in transfer operations here as this is not a suitable transport mode due to the large flows involved and because terminals do not believe this to be a preferred mode of transport.

- Step 1: Generation of energy in countries with abundant natural energy resources;
- Step 2: Ammonia transport by sea from solar/wind-rich areas to Europe;
- Step 3: Storage and transhipment from ocean-going vessels to storage tanks in the Netherlands;
- Step 4: Ammonia cracking to produce hydrogen;
- Step 5: Transport of ammonia by pipeline, barge, rail and road.

Each step carries specific risks and is subject to (international) laws and regulations. For an ammonia terminal, this also includes certain supply chain responsibilities in relation to the different steps in the ammonia supply chain. Serious incidents involving ammonia occurring in the supply chain (globally) are expected to impact Dutch ammonia policy and legislation. The document “VOTOB Safety Standards in the Ammonia Supply Chain” details the various steps in the supply chain, the associated laws and regulations and how a terminal manager can realistically fulfil the requisite supply chain responsibilities.

1.3 Company or customer frameworks

A terminal may be part of a larger organisation that operates several terminals and/or combines terminal operations with adjacent activities (transport, fuel trade). This organisation may then impose the frameworks within which the terminal has to operate. For example, this may include general safety rules (Golden rules of safety, Safety fundamentals etc.), codes of conduct or mandatory training programmes. However, even when the terminal operates independently, it will have to set its own safety and environmental frameworks: this is expected pursuant to European and Dutch legislation.
In addition, customers (product owners) may have requirements regarding the quality and safety of the terminal's operations. This often means that the terminal needs to be ISO 9001 (quality), ISO 14001 (environment) and/or ISO 45001 (safety) certified.

2. Processes and installations

If ammonia is going to be used as a hydrogen carrier, several ammonia terminals will have to be established in Dutch seaports where ammonia storage and transhipment can take place. Similar processes will be used at each of these terminals. This chapter outlines these processes, including the areas of concern that emerged during the interviews with terminal managers.

2.1 Process description

An ammonia terminal consists of several components, each of which is subject to specific requirements. Ammonia is delivered by ocean-going vessels as cold ammonia, i.e. cooled to a liquid under atmospheric pressure. Transhipment takes place by means of loading arms, for which procedures and safety features are established in accordance with the PGS 12, such as leak detection. Prior to transport to the hinterland/customers or prior to its use, the ammonia is cooled to a liquid in atmospheric storage tanks at a temperature of -33°C. This storage of ammonia is in accordance with the PGS 12 guidelines: a double-walled steel tank and a concrete outer wall to protect the inner steel tanks from external impact (full containment). These tanks must be designed specifically for ammonia. To ensure that the ammonia in the storage tanks maintains the correct temperature, the ammonia storage facility is cooled using refrigeration compressor(s). To prevent Stress Corrosion Cracking (SCC) in ammonia storage tanks, no oxygen may enter the tanks. The water content of the ammonia must also be precisely controlled (above 0.2 wt.%).

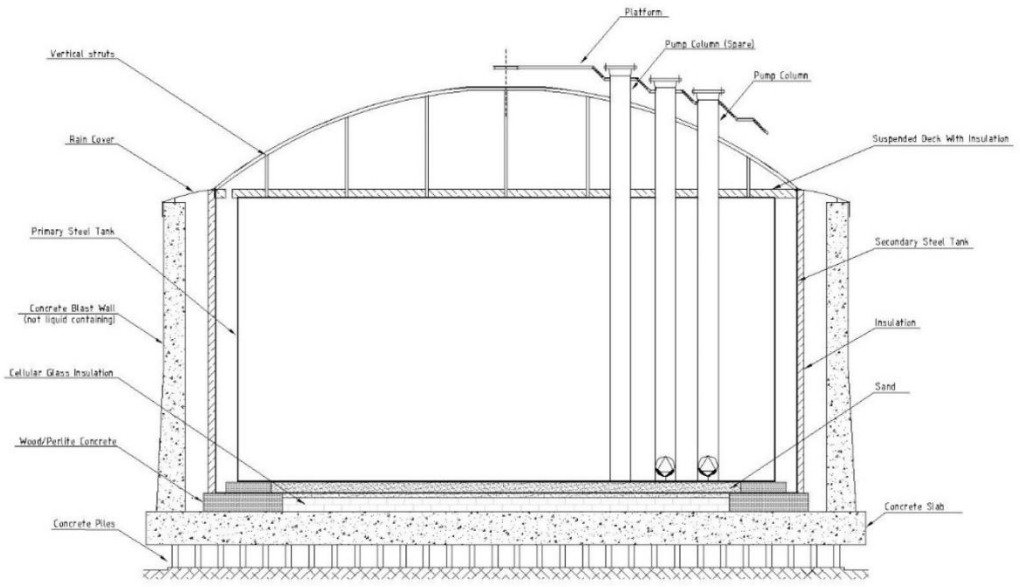

Figure 2.1 Storage tank as prescribed in PGS 12 (source: PGS 12)

The ammonia is transferred from these storage tanks to a cracker or to various modes of transport: ocean-going vessels, barges, tanker trucks and rail tankers with the associated transhipment facilities. Some of these transport modes ship ammonia as Warm ammonia, i.e. under elevated pressure, compressed into a liquid at ambient temperature. In this case, the ammonia is first heated by a heat exchanger before it is transferred. Ammonia gas detection is present at both loading and heat exchanger in accordance with the PGS 12.

When ammonia is cracked to produce hydrogen at the terminal, this requires a dedicated process plant. To crack ammonia, it is heated to high temperatures. To do this, the cold ammonia is first heated by a heat exchanger. For process continuity reasons, the warm ammonia can be stored in a pressurised tank before entering the process vessel. Ammonia cracking breaks down ammonia molecules into hydrogen and nitrogen in accordance with the following chemical reaction: $2NH_3 \rightarrow 3\ H_2 + N_2$ The hydrogen is cooled by (the same) heat exchanger to around ambient temperature and pressurised by a compressor for transport. Hydrogen is exported from the terminal through the port's hydrogen pipelines.

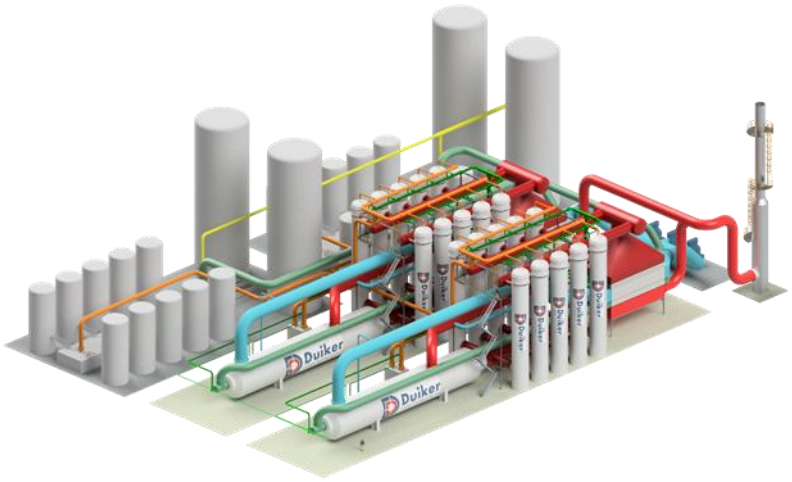

Figure 2.2 Example of an NH_3 cracker AHC plant – Source: Duiker Clean Technologies

Ammonia is transported between the different installations within the terminal via pipelines. Pumps located in the ammonia tanks are used for this purpose. The ship's pumps are used to load the ammonia. Guidelines for both piping and any additional pumps and compressors are included in the PGS 12.

Annex 1 contains a detailed plant description of an ammonia terminal.

3. Management and organisation

This chapter looks at how operations at the terminal are organised and how the management team provides the necessary leadership. Fundamentally, this is no different from a fossil fuel terminal, so the focus here is on specific aspects relating to ammonia terminals.

3.1 Management team

Providing leadership for a converted or start-up ammonia terminal brings additional challenges. It is important that the Management Team (MT) has a shared vision for the terminal's future and communicates it to the rest of the organisation. Safety should be leading in this vision.
In addition, managers must be able to initiate and permanently implement the desired changes right down to the shop floor, including contractors. This requires specific knowledge and competences within the management team, both technical, organisational and on the human level. The following list of key core competences should at a minimum be represented on the MT for the sake of safe operations:

Safety awareness
The MT must be able to let safety be leading in the organisation and put it above financial[2]interests: "You either work safely or you don't work at all". To this end, all MT members should have a high level of safety awareness, especially regarding the risks and hazards of ammonia. To this end, the entire MT should initially undergo risk awareness training (ammonia hazard awareness or related training). This involves not only factual knowledge of ammonia-related risks and regulations, but also the necessary culture and employee behaviour required to maintain a high level of safety.

Technical and chemical (process) knowledge
Chemical and engineering processes are the terminal's core business. The safety of the terminal is highly dependent on the effective control of these processes. Knowledge in this area and experiential expertise to appreciate risks *must* therefore be secured in the MT.

Leadership
Leadership is needed to implement and sustain change, and to make effective decisions in which safety is prioritised appropriately.
A terminal manager must have a strong affinity for technical and chemical safety to fulfil his/her role as a leader of a high-risk plant. In addition, he/she must be able to manage both in-house personnel and contractors working at the terminal. MT members are expected to be able and willing to listen effectively to staff and initiate concrete actions in response to safety-related concerns and improvement proposals. MT members also have an important role model function in terms of their behaviour with regard to safety.
Personal leadership training can help increase overall leadership skills. This will, for example, cover communication skills, team management, decision-making and change management.

Knowledge of laws and regulations
Compliance with laws and regulations is the terminal's licence to operate. The MT must have extensive knowledge of laws and regulations to be able to implement the terminal's policy within the applicable legal frameworks and to respond quickly to changes in laws and regulations. Effective contacts should also be maintained by the MT with (internal and external) regulators, supervisory authorities and sector organisations, with the aim of broadly sharing knowledge relevant to the safety of sector companies and supply chain partners. The MT needs to understand the importance of this.

Culture and behavioural influence
Human error is often at the root of accidents. In addition to having an eye for technology, chemistry and processes, the MT therefore must also have an eye for the human factor in the organisation, and be able to

[2] See the analysis and conclusions regarding safety management in the Odfjell Terminals Rotterdam Investigation into Safety Report 2000-2012.

influence it. The MT's focus on culture and behaviour should be permanently maintained by making it an essential part of the MT's agenda. Chapter 4 discusses the safety culture topic in more detail.

Personnel management
It is vital that terminal staff have the right knowledge and competences to work with toxic substances, that they have the right safety mindset and that they feel connected to the organisation. This means having a selective and strict personnel policy and a socially safe workplace at the terminal. This applies to all staff working at a terminal, including contractor or partner staff.

3.2 Safety management system (SMS)

To minimise risks in the operation of an ammonia terminal, fixed procedures and work instructions must be adhered to in accordance with a safety management system (SMS). An SMS consists of two parts: a major accident prevention policy (PBZO), which describes the general goals and responsibilities of handling dangerous substances, and a safety management system (SMS), which describes how the PBZO is put into practice.

Because an ammonia import terminal is considered a Seveso high-threshold establishment (>200 tonnes of ammonia), the development and correct implementation of an SMS is mandatory. The PGS 6 instructions can be used for this purpose. This guideline recommends that the NTA 8620:2016 *Specification of a safety management system for major accident hazards* be used for this purpose.

The PBZO includes:

- Prevention policy objectives, such as protecting people and the environment, taking responsibility for a high level of safety, creating safety awareness, etc.;
- Prevention policy principles, such as adhering to the Plan-Do-Check-Act (PDCA) cycle; and
- An outline of the main risks, including the identification of the opportunities and impacts associated with activities at the terminal.

The SMS is a comprehensive document broadly structured as follows:

1. General information
2. Organisation structure and staff
3. Hazards and the assessment of risks, for example using the HAZOP method
4. Monitoring the implementation of the SMS
5. How to deal with change in actual practice
6. Emergency planning
7. Monitoring and control of safety policy performance

The SMS potentially can be combined with a quality and/or environmental management system.

The following section discusses some areas of concern raised by the terminal managers interviewed relating to the management system’s procedures.

3.3 Specific procedure-related concerns

Maintenance procedures

All of the terminal’s installations require periodic maintenance. In this respect, there are clear differences from other storage and transhipment terminals, such as terminals handling oil and petroleum products.
Maintenance of an ammonia storage tank takes much longer because it involves cryogenic storage and no oxygen should be present in the tank after maintenance to reduce SCC. Some operations will also have to be performed wearing respiratory protection equipment. The various steps to be followed during maintenance and the decommissioning/commissioning of tanks are listed in the PGS 12.
Tanks for transport, such as road and rail tankers, must not contain any oxygen for the same reason. Changing means of transport represents a risk for oxygen ingress. If they are not solely designated for ammonia transport, a flushing procedure with nitrogen and control of residual oxygen content is necessary, as well as flushing with ammonia gas to prevent the temperature of the initial liquid ammonia from dropping significantly below zero degrees Celsius. It is therefore safer to work with dedicated means of transport.

Ammonia quality control

It is necessary to know the exact properties of ammonia before storing it, and to check that they are within the specifications of the terminal's tank and piping systems. The ammonia's water content is especially important in relation to SCC. The terminal will need to have procedures in place for this purpose. Also see the VOTOB Product Acceptance Guideline and associated training programme.

Loading and unloading procedures

Ammonia loading and unloading is generally considered risky. A quantitative risk analysis (QRA) of this process therefore identifies it as having a high impact on the risk profile. In the worst case, leaks may occur during the process, and in the case of ammonia, this could lead to significant safety risks.
During loading and unloading operations, it is necessary to cooperate with third parties and you must be able to rely on the integrity of the means of transport being connected. The loading and unloading procedures in force at the terminal as well as at the means of transport, including alerting and emergency procedures, should be clear and complete and be known and understood by all involved parties. The procedures should clearly define the responsibilities and duties of staff at the terminal and at the means of transport.
When a ship is being loaded/unloaded, a standard checklist for transferring toxic substances (e.g. SIGTTO or the ADN ship-shore checklist) that can be used to verify that all safety conditions are met for both the terminal and the ship must be used.
Most critical is the situation in which a ship pumps the ammonia to the terminal with its own pumps. It must not be possible for a situation to arise where the terminal itself is unable to stop the process. It must be possible to stop the transfer with an emergency stop if, for example, the pressure or liquid level in the storage tank becomes too high.

4. Safety culture

The safety culture is a derivative of the company's organisational culture. It is partly influenced by the norms and values that employees in the organisation bring from their own culture and by the circumstances in which the organisation finds itself. So it is not an isolated culture, nor is there a one-size-fits-all solution to achieving an organisational culture that puts safety first. Working on culture is people work and it involves all layers of the organisation.

Figure 4.1 Three levels of culture that influence safety management in an organisation.
Source: Coconut Blue Culture Based Safety Management

4.1 Suggestions for working on a safety culture

How to work towards creating an excellent safety culture at a terminal is not prescribed anywhere. First and foremost, safety must be discussable at all levels of the organisation, everyone must feel heard and visible action must be taken on identified shortcomings and suggestions for improvement submitted by staff. This also applies to contractor personnel working at the terminal. This seems obvious, but practice is recalcitrant. Before starting up an ammonia terminal, it is therefore indispensable to think about how the desired safety culture will be conveyed to all staff.
The following suggestions for creating a proper safety culture emerged from the interviews:

- **Safety culture training:** Teach the skills needed to thrive in a culture in which openness, daring to be vulnerable and responsibility are key pillars. Managers must learn how to initiate, stimulate and coordinate the path to be followed to achieve this. The goal must be to climb up towards the highest rung on the Safety Culture Ladder.
- **Personal leadership training:** Attend a personal leadership training course, to gain insight and tools to strengthen communication in the workplace. Think about looking at yourself critically and giving and receiving feedback. Moreover, personal leadership training promotes better cooperation.
- **Internal review:** Include behaviour and culture in regular staff appraisals to help ensure the creation of an excellent safety culture.
- **Toolbox meetings:** Low-threshold discussions between employees and managers about the work and possible areas for improvement related to this contribute to openness and a culture where people dare to speak out.

- **An outdoor training course for the entire staff:** Through mandatory participation in 2-3 days of outdoor training for all staff, everyone learns what kind of culture is present in the company. In addition, this gives staff good insight into how people behave in a group (assertive vs thoughtful).[3]
- **A sector-wide programme for sharing knowledge and experience:** By sharing knowledge and experience on working with ammonia within the sector, terminals can learn from each other. For example, a discussion of (near-miss) incidents can be organised regularly, and/or a thematic meeting in which terminal managers themselves can cover topics as required by the group. Such a programme could be initiated by the VOTOB, Deltalinqs (Dutch industry association for companies operating in ports and industrial sectors) and VNCI (Dutch Chemical Industry Association), for example. This contributes to an sector-wide safety culture.

4.2 Methodologies for improving safety culture

Improving safety culture is something that has been high on the wish list of many technical-operational organisations over the last decade. To this end, various tools have been developed that can help improve a safety culture, and there are just as many consultants and training programmes that are happy to proclaim from the sidelines how to create an ideal safety culture. This should be treated with common sense.
Relevant methodologies are briefly discussed below.

The safety culture ladder

A well-known tool for measuring improvement is the safety culture ladder. The safety culture ladder consists of 5 rungs. The more responsibility, reflection and investment in safety the higher the score. The rungs indicate the stage of development the organisation has achieved in terms of safety awareness.

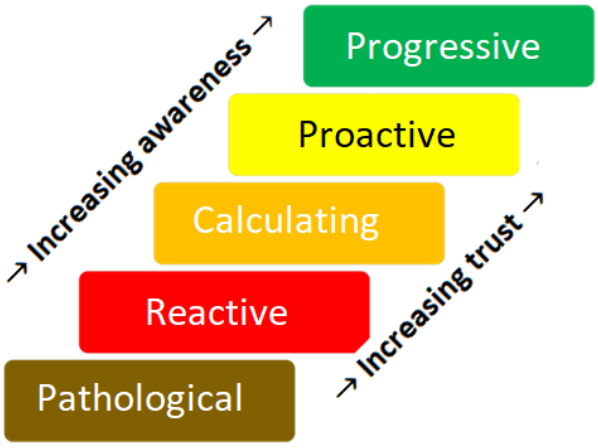

Figure 4.2 The Safety Culture Ladder.

The ladder in a simple way shows where there are opportunities in relation to safety and/or a safety culture. It provides a basis for having useful conversations about safety within an organisation.

NOTE. The ladder should only be used with due consideration and expertise. The model is not intended to be used as a diagnostic tool. The model has evolved from a descriptive/educational model, to a self-assessment tool (Hearts & Minds), an audit tool and now also into a way to certify and assign functions (Safety Culture Ladder from NEN) . As a result, an originally good and useful idea has degenerated into a commercial tool in which obtaining a certificate has been elevated as a goal over improving the safety culture.

New methodologies

New safety engineering methodologies are betting on resilient organisations that can handle change well (resilience engineering). The methods focus on what goes well and why, rather than incidents and mistakes.

[3] A possible source of trainers for similar training is: https://in-tense.nl/

This creates a safe and positive working atmosphere. Two well-known creators and promulgators of these methods are:

- Prof. Erik Hollnagel: Safety I and Safety II thinking (Functional Resonance Analysis Method (FRAM) FRAM – the Functional Resonance Analysis Method for modelling non-trivial socio-technical systems, 2017).
- Prof. Sidney Dekker: “Just Culture” and “Safety Differently”. (Home – Sidney Dekker)

5. Staff

Working at an ammonia terminal requires specialised knowledge and skills. Staff must have acquired this knowledge and these skills before the terminal becomes operational. Learning on the job is not an option when it comes to ammonia.

> *"You cannot go through a learning curve as soon as you start working with Ammonia: you have to be ready from day 1!"*
> *André Meulmeester, former Terminal Manager OCI Terminal Europoort*

This chapter identifies areas of focus for the personnel policy and discusses education and training programmes that are appropriate for ammonia terminal staff.

5.1 Personnel policy

Basically, an ammonia terminal does not need to have an organisational structure that differs from an oil or gas terminal. However, the positions in the organisation and the associated knowledge and competences should be well suited to the specific challenges of an ammonia terminal. For a start-up ammonia terminal, this may also mean hiring new staff, saying goodbye to existing staff and that staff must be retrained or given additional training. This requires an appropriate personnel policy.

An assessment must be conducted for *existing staff* who have experience working with fossil fuels, to determine whether they have the right mindset to deal with the risks of working with ammonia. If this is lacking, then it is simply irresponsible to continue to deploy these people.

Finding suitable *new staff* may be a challenge given the current labour market. Terminal managers indicated in the interviews, that as far as they are concerned, mastering the Dutch or English language (the working language at the terminal) is a critical competence from a safety perspective. For *all* new staff members, an onboarding programme that devotes ample attention to ammonia hazards is required.

Training, retraining and additional training in working with ammonia should be initiated well in advance for all staff. Taking one year prior to the start-up of an ammonia terminal to fully train or retrain staff or to provide additional training definitely is not excessive.
The terminal's building contractor will provide a training programme to instruct staff on the operation of the terminal to be built. However, in addition, terminal management will have to determine how this programme must be supplemented to fully prepare staff for their work.
Ideally, staff should gain experience at an existing ammonia terminal in advance, by spending a period of time there. However, this is not always feasible for every terminal.

5.2 Training

Below is an explanation of some training programmes that effectively match the knowledge and competence requirements for working at an ammonia terminal. These courses should be seen as normative in terms of substance and level. However, naturally this does not exclude comparable courses.

University of Applied Science/Higher Academic Education (HBO/WO) chemistry/physics/mechanical engineering

Managers in the field of operations, engineering and processes must have completed an HBO or WO education that enables them to understand all physical and chemical laws and processes required to safely store ammonia. With this knowledge, they can draft policies and review decisions to secure safety over the short and long-term.

Advanced Safety Engineering(HVK)/Intermediate Safety Engineering (MVK)/Management of Health & Safety and Environment (MoHSE)

Managers and employees in HSE positions develop the safety policy, the strategy to implement it and monitor compliance. They should be well-versed in knowledge areas such as working conditions, process safety, environmental safety, and safety culture and behaviour. An HVK or MoHSE diploma is recommended for managerial HSE positions; an MVK diploma is standard for implementing HSE functions (e.g. supervision & inspections, audits, risk analyses, inductions, etc.).

Intermediate Process Operator Certification B (Vapro B)

The day-to-day operation of a terminal requires personnel with extensive process operator training. Essential for an ammonia terminal is mastery of:

- Laws of physics relating to phase transitions and liquefied gases;
- Chemical reactions of ammonia and their effects; and
- Ability to think in terms of processes.

With this knowledge, employees can understand how scenarios arise and why. Every action can affect the ammonia storage process and an operator must be able to think of the attendant consequences. The training also provides the basic knowledge required to fully participate in an organisation with a progressive safety culture where health and safety are key and fully integrated into the work.
An important aspect of an operator position is that it usually comprises repetitive work, where there is a risk of numbness potentially leading to poor/sloppy work execution. Overqualified employees for such positions increases this risk. Also see Section 5.5.

5.3 Training programmes and courses

Every terminal should have a training matrix that defines which training and courses are mandatory for which positions. An existing terminal typically already has such a training matrix in place, which will therefore need to be supplemented with training courses specific to ammonia. There is as of yet no fixed curriculum of training courses for ammonia terminal personnel in the Netherlands, so for now the training matrix will have to be composed of custom training courses that specifically address working with ammonia, and generic training courses offered by training institutes (e.g. VCA (Safety Certification for Contractors) or conducting gas measurements). Regular repetition of training and practical exercises are essential to keep knowledge and competences up-to-date.

The following is a list of training courses that fit into an ammonia terminal training matrix.

1. Custom training courses

- **General ammonia risk awareness training**

For a toxic substance like ammonia, it is important that *everyone* at the terminal understands the risks of this substance, how these risks may be reflected in their own work activities and how to act in case of an ammonia incident. General ammonia risk awareness training imparts this knowledge. It covers:

- General information on preventive measures;
- Causes of accident scenarios;
- A select number of accident scenarios in accordance with the PGS 12;
- The impact scenarios from the PGS 12; and
- Repressive measures;
- (Specified for all employees): what to do in case of an incident.

- **Scenarios and motivation for the measures in the PGS 12**

While some support positions do not require in-depth knowledge of the PGS 12, many technical and operational positions do. Staff in these positions will need additional training for this purpose. This training provides knowledge of:

- All accident scenarios in accordance with the PGS 12;
- All impact scenarios from the PGS 12;
- Causes of accident scenarios;
- Substance and motivation of preventive measures; and

- Repressive measures.

- **Ammonia-specific material science course (SCC)**

Operations involving ammonia carry a specific risk of Stress Corrosion Cracking (SCC). Some positions require specific knowledge of all facets affecting SCC, SCC prevention and detection. This course covers which materials are suitable for use with ammonia and under what conditions, so as to prevent SCC and plant failure as a result.

- **Emergency plant training for ammonia incidents**

Personnel frequently present at the terminal should know how to act in case of incidents to minimise the consequences of ammonia leaks. A course that deals with the emergency plan contributes to this goal. This course includes:

- Knowledge and understanding of diffusion models within and beyond the facility;
- Information on reporting to and invoking emergency services;
- Knowledge about protecting one's own facility and neighbours; and
- Information on repressive options in case of incidents.

- **Company Emergency Response (CER) – Basic & Ammonia specific**

In addition to basic CER knowledge, CER officers at an ammonia terminal need specific knowledge on injuries resulting from incidents involving ammonia, such as freezing injuries and impairment of respiratory organs and eyes.

2. Generic training courses

- **Safety culture training**

A safety culture training course provides insight into how norms and values are determining factors for safety in the organisation, the elements of a good safety culture and how to collectively work on this.

- **VCA Basis: Basic Safety Certificate and VCA VOL: Safety for Supervisors/Leadership Certificate**

Working safely in a high-risk environment requires basic factual knowledge so that there is a common starting point for working safely (“This is how we do this”). The Safety Checklist Contractors (VCA) courses provide the required basis in the Netherlands. Staff with this basic knowledge can participate fully in an organisation where safety and health are key and fully integrated into the work.
For managerial positions, a VCA VOL is a requirement, while VCA Basic is required for other positions.

- **ADN/ADR/RID**

In positions that involve the transfer of ammonia , knowledge of laws and regulations on the transport of ammonia by water, road and/or rail is required.

- **Independent respiratory protection**

With a course on the safe and responsible use of self-contained breathing apparatus, a supervisor can provide personal protection during activities where ammonia could be released (first line break etc.), and employees must use it where required.

- **Flange fitter**

A course on responsible pipe flange assembly and disassembly ensures that in day-to-day operations and maintenance, the integrity of the ammonia pipe is ensured after the work has been completed.

- **Gas measurement**

A course to safely and responsibly determine whether the working environment is free of toxic substances and qualitatively suitable for breathing ensures that installations are delivered safe for performing maintenance work.

- **Product knowledge and product acceptance training**

This training is offered by the VOTOB Academy and aims to transfer knowledge of the product and the product acceptance process, enabling practical product and process implementation and understanding.

5.4 Education and training matrix

Below is a sample education and training matrix as it may be implemented at an ammonia terminal. It specifies the level of knowledge and competence that should be present for each position. The proposal is based on experience gained at existing ammonia storage and transhipment facilities and discussions in the PGS 12 working group. Elements from this matrix can be used by companies to supplement their own matrix.

Sample education and training matrix

Management team

Sample education and training matrix		Management Team						
Required knowledge or competency level relating to terminal safety	**Explanation**	**Terminal Manager**	**HSE Manager**	**Operations Manager**	**Technical Manager**	**Process Techn. Manager**	**Other MT members (HR, Finance, Commercial etc.)**	**Repeat / update cycle**
Education								
HBO/WO chemistry/physics/mechanical engineering	Risk assessment and consideration	X		X	X	X		
HVK/MoSHE	Knowledge of risks, methods for safety control		X					
Process operator certification B	Physical understanding of fase transitions and process mindedness. Understanding your actions.							
Trainings and courses								
Safety culture training	Facilitating continuous process of improvement (Safety Culture Ladder)	X	X	X	X	X	X	X
Ammonia risk awareness training	Risk aware in all decisions	X	X	X	X	X	X	X
Scenarios and motivation for the measures in the PGS 12	Knowledge of risks and corresponding responsibilities	X	X	X	X	X		X
Emergency plan training - Ammonia specific	Adequate control of accidents and consequences	X	X	X	X	X		X
VCA Basis of VCA VOL (leadership positions)	Knowledge of general safety rules. Starting point of continous improvement	X	X	X	X	X		X
CER Basic + Ammonia specific	First aid for ammonia specific injuries	X	X	X	X	X	X	X
ADN/ADR/RiD	Knowledge of risks and corresponding responsibilities	X	X	X	X	X		X
Specific course on SCC prevention	Risk aware in operation, maintenance and design			X	X	X		X
Independent respiratory protection	Personal safety during special operations (First break etc)							X
Flange fitter	Securing integrity during (un)coupling loading systems, pipes/hoses and appendages							X
Gas measurement	Securing installations - judging unexpected situations							X
Operations Management	Continous improvement tool, facilitating 24-7 correct decision-making and actions							

Other staff

Sample education and training matrix		Other staff									
Required knowledge or competency level relating to terminal safety	**Explanation**	**SHE officer**	**Operator**	**Shift supervisor**	**Operations Supervisor**	**Work planner**	**Mainte-nance Engineer**	**Supervisor**	**Mainte-nance Technician**	**Process Engineer**	**Repeat / update cycle**
Education											
HBO/WO chemistry/physics/mechanical engineering	Risk assessment and consideration									X	
HVK/MoSHE	Knowledge of risks, methods for safety control	X									
Process operator certification B	Physical understanding of fase transitions and process mindedness. Understanding your actions.		X	X	X						
Trainings and courses											
Safety culture training	Facilitating continuous process of improvement (Safety Culture Ladder)	X	X	X	X	X	X	X	X	X	X
Ammonia risk awareness training	Risk aware in all decisions	X	X	X	X	X	X	X	X	X	X
Scenarios and motivation for the measures in the PGS 12	Knowledge of risks and corresponding responsibilities	X	X	X	X	X	X	X		X	X
Emergency plan training - Ammonia specific	Adequate control of accidents and consequences	X	X	X	X					X	X
VCA Basis of VCA VOL (leadership positions)	Knowledge of general safety rules. Starting point of continous improvement	X	X	X	X	X	X	X	X	X	X
CER Basic + Ammonia specific	First aid for ammonia specific injuries	X	X	X	X	X	X	X	X	X	X
ADN/ADR/RiD	Knowledge of risks and corresponding responsibilities	X	X	X	X						X
Specific course on SCC prevention	Risk aware in operation, maintenance and design				X	X	X	X		X	X
Independent respiratory protection	Personal safety during special operations (First break etc)		X	X	X						X
Flange fitter	Securing integrity during (un)coupling loading systems, pipes/hoses and appendages		X	X	X				X		X
Gas measurement	Securing installations - judging unexpected situations	X	X	X	X						X
Operations Management	Continous improvement tool, facilitating 24-7 correct decision-making and actions			X	X						
Training on terminal main roles											
Storage			X	X	X						X
Distribution (pumps en ldg systems)			X	X	X						X
Transshipment import/export cryogenic			X	X	X						X
Warming ammonia			X	X	X						X
Transshipment warm			X	X	X						X
Rail loading			X	X	X						X
Scenario's PGS 12 toolboxes	Knowledge and understanding of scenarios - prevention and applied measures	X	X	X	X	X	X	X			X
Ammonia spill control		X	X	X	X						X

5.5 Main operator tasks

Operators play a pivotal role at an ammonia terminal. A good practice is to give operators different tasks and deploy them on a rotational basis. This prevents numbness, which is a known cause of making mistakes in operational positions.
An operator must be trained and thoroughly familiarized with each of these tasks. Depending on which installations are present at the terminal, the following main tasks can be distinguished (non-exhaustive):

1. Storage
2. Distribution (pumps and pipe systems)
3. Ship cargo import/export cold
4. Heating ammonia
5. Ship loading of warm ammonia
6. Rail loading
7. Toolboxes for PGS 12 scenarios
8. Ammonia leakage control

Training should be repeated periodically, e.g. every four years.

5.6 Contractor staff

Besides in-house staff, specific work may also be carried out by contractor personnel, as long as the essential positions are staffed by in-house personnel. In working with contractors/subcontractors, procedures should be in place to ensure that the work can be carried out safely and that contractor/subcontractor personnel conform to the safety rules and rules of conduct rules at the terminal.

All contractor/subcontractor personnel must attend a terminal safety induction briefing.
In addition, specific training may be made mandatory, ranging from general training for safe working (e.g. VCA) to specific ammonia-related training courses. In working with regular contractors, consideration could be given to having them participate in terminal training programmes.
For contractor staff, the working language for communication at the terminal also is a key concern. The foreman of a contractor’s team at a minimum must be able to communicate in the terminal's working language.

6. Dealing with neighbours

This chapter focuses specifically on dealing with “the neighbours”. An ammonia terminal is likely to face critical neighbours because of ammonia’s toxic properties. This can escalate into nasty situations or even lawsuits that demand a lot of time and energy from terminal management. It is therefore important to be alert to this and to be proactive in this regard. This requires specific skills and awareness on the part of all terminal staff. This chapter discusses the parties that a terminal may have to engage in discussion and how contact with them can or should be established.

6.1 Neighbouring businesses

A so-called “domino establishment”, due to its proximity to another Seveso establishment, can increase the risk of a major accident at surrounding sites. This is called the domino effect. Companies designated as domino establishment are obliged to implement the following measures (Article 4.13 of the Living Environment Activities Decree):

- They must exchange the information necessary to take account of major accident risks in their prevention policy, safety management system, safety report and internal emergency plan.
- They work together in providing information to the public and nearby businesses and providing data and records for the development of a disaster response plan by the Safety Region.

The following steps are required for a designated domino establishment:

1. Determine whether an impact could lead to domino scenarios beyond the establishment. The DCMR methodology can be used for this purpose.
2. Draft an information letter for (Seveso) neighbouring companies.
3. Consult with (Seveso) neighbouring companies on domino scenarios and preparation.

In terms of domino effects, the impact of toxic clouds are not relevant. Toxic clouds do not cause neighbouring plants to fail. However, it is useful for a neighbouring company to know that in case of an emergency, a toxic cloud could be released and reach the neighbouring company's facility. If the neighbouring company is informed of this, it can take measures to prevent exposure to a toxic cloud.

Step-by-step plan – receiving domino establishment

The moment a letter about domino effects arrives, there is new information that needs to be processed in accordance with the Safety Management System. The following global steps are then carried out:

1. After receiving the domino information letter, enter into discussion with the responsible party.
2. Assess the consequences of the domino effect and request any missing information needed to share these consequences:
    a. Which plants lie within range of the domino effect
    b. What damage can occur
    c. What are the possible measures
    d. What information is needed in the context of the emergency plan
3. Incorporate the information into the safety management system, for example:
    a. The safety report
    b. The emergency plan
    c. Staff education
    d. (Possibly) take other measures, see point
4. (Jointly) assess whether the domino effect is physically possible/realistic. Practice and model-based reality usually do not match. For example, shielding of heat radiation at installations due to the presence of obstacles.

Ultimately, Seveso establishments must take all reasonable measures to prevent a major accident.

Potential hazards from beyond the site could come from the following existing activities:

1. Transport routes: There may be several Seveso establishments and transport routes with hazardous substances in the immediate vicinity of the terminal that pose a potential risk to the facility.
2. Adjacent industries: There may be Seveso establishments containing hazardous substances in the immediate vicinity of the terminal.

Risks can be assessed on the basis of the Atlas of the Living Environment.

6.2 Local community

Because of the large impact areas of a toxic ammonia cloud, communication with the local community must be a regular part of an ammonia terminal's operations. It is important to engage and maintain dialogue with the local community to create and maintain trust.
This contact with the local community starts as early as the initiation of the licensing procedure for the establishment of an ammonia terminal or the conversion of an existing terminal. The Environmental Planning Act refers to this as “participation”. This is mandatory for governments, but not for companies that have a plan or an idea. However, participation is nevertheless strongly encouraged.
There is much concern about developments around the energy transition, especially the use of ammonia as a hydrogen carrier and fuel. The probability of an incident is small, but because of the potentially large (up to kilometres) impact on the surrounding area, there is a lot of fear and concern on the part of the local community within the impact area. Trust must be gained by engaging the local community. Both during a licensing procedure, but also during the production phase, it is advisable to think about how to stay in touch with your neighbours as a company. Not only management plays a role in this, but other staff who have personal contacts outside working hours and talk with their neighbours about work at the terminal, as well.
The licensing procedure, usually starts off with a stakeholder analysis: what are the parties you will become involved with as a company. Or more specifically, which parties will a company encounter in their working or living environment.
Providing transparency about the proposed work, and actively addressing concerns, will build confidence within the local community. Living Environment Information Point[4] has information illustrating how a company can effectively implement this approach.

The sector association can be used to generally promote confidence within the local community by drafting a collective code of conduct for the sector[5], to which its members conform. Furthermore, companies located in each other's vicinity can cooperate with the respective port authority in establishing contact with the local community.

6.3 Emergency services and local authorities

Initially, the terminal itself must be able to deal with incidents at the terminal. This requires the right expertise. Response options in an ammonia incident are limited: the options mentioned in the interviews were: Cover with a tarpaulin (ammonia pool) and disperse (ammonia in gaseous form, dispersion with the help of a monitor positioned at the correct angle to detect the gas). However, it is especially important to house personnel in safe havens and to instruct and evacuate local residents.
Company emergency plans should be coordinated with local emergency services and authorities. As yet, these are not always well prepared to anticipate ammonia incidents. People must therefore be briefed on potential actions after being alerted about an incident.
The initial course of action involves instructing local residents and evacuating the local community based on the speed and direction of the gas cloud. At locations in the Netherlands where the chemical industry is clustered, such as in the Europoort, Sloegebied and Chemelot, joint firefighting facilities should be involved. “Ammonia core teams” could be established within these organisations if multiple ammonia businesses are developed in these areas. Naturally, the periodic joint exercise of an ammonia scenario is recommended.
In summary, for the time being, as a terminal it is necessary to *actively* ensure that the local emergency services and authorities have (or are developing) sufficient expertise to act effectively in the event of an ammonia incident at the terminal.

For incidents beyond the terminal, for example during transport by rail or road, the Dangerous Substances Advisor of the relevant Safety Region is in charge. This person must also have the right expertise, but whether

[4] Participation in the Environmental Planning Act | Living Environment Information Point
[5] Example of sector codes of conduct: ElementNL_Code of conduct2.pdf

this is currently the case is unknown. Terminal managers indicated that they can always give advice on incidents during transport if asked, but do not see a formal role for terminals here.

7. Conclusions and recommendations for the sector

Antea Group has drawn the following conclusions and recommendations from the conversations, interviews and desk research conducted for the development of this curriculum:

1. At an ammonia terminal, **safety awareness** *among all personnel* should be even higher than at an oil terminal, because mistakes in an ammonia process are much more likely to result in accidents. Safety awareness must be constantly worked on. Staff who do not have the right safety mindset cannot be tolerated at the terminal.

2. The chemical properties of ammonia present special challenges for plant management and maintenance. The requisite **technical and chemical knowledge** must be in ample supply at a terminal, including among management.

3. An **education and training matrix** that identifies the education and training required for each position is mandatory for an ammonia terminal.

4. For **contractors** who will be working at the terminal, strict procedures must be in place to ensure that work is carried out safely and that the rules of conduct at the terminal are observed.

5. An ammonia terminal does not stand alone: among other things, it is a link in the ammonia supply chain, part of the European energy supply and part of the living and working environment of others. **"Environmental awareness"** on the part of terminal management therefore is essential.

6. Working with dedicated ammonia tanker trucks, ammonia barges, ammonia pipelines and ammonia tanker vessels is recommended from a safety perspective.

7. The sector association(s) (VOTOB, Deltalinqs, VNCI...) can play a far-reaching role in **supporting start-up ammonia terminals.** This includes:
   - Setting up a programme (or establishing a working group) for sharing (near-miss) incidents and good practices among ammonia terminal managers;
   - Establishing a sector code of conduct for dealing with neighbouring stakeholders;
   - Developing sector-wide training programmes and courses, where custom training currently is still used;
   - Establishing and maintaining contacts with international knowledge institutes and associations to contribute to the development of global safety standards for ammonia terminals and transport;
   - Further developing this curriculum into a sector standard to which members must conform.

8. As terminal (jointly and possibly in cooperation with the relevant port authority) actively ensure that the **local emergency services and authorities have sufficient in-house expertise** to act effectively in the event of an ammonia incident at the terminal, or help them to develop this expertise by sharing the course of action required in an emergency situation and by practicing together.

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Annex 1: International knowledge institutes

Internationally, there are several associations and/or institutes that share knowledge relating to the (transport and storage of) ammonia topic. A few of these are listed below.

American Institute of Chemical Engineers (AIChE)

The AIChE has several meetings relating to ammonia safety, such as the Ammonia Safety Symposium. They also share information on incidents that have taken place worldwide, but you can only access this information if you are an AIChE member.
AIChE | The Global Home of Chemical Engineers

Ammonia Energy Association (AEA)

The AEA is a global non-profit sector association promoting the responsible use of ammonia in a sustainable economy. The AEA organises various knowledge-sharing events in the form of online workshops and in-person conferences.
Ammonia Energy Association

Fertilizers Europe

Fertilizers Europe represents the interests of the majority of mineral fertiliser producers in the European Union. They also meet to determine the requirements ammonia terminals are expected to meet. In this context, they have a number of publicly accessible documents on operations involving ammonia: storage, train loading, etc. Ammonia incidents also are a topic of discussion here. This information is not publicly available, i.e. members only.
Home - Fertilizers Europe

Chemical Distribution Institute (CDI)

The CDI is responsible for inspecting and controlling the global supply chain for the transport and storage of bulk and packaged chemicals. CDI was founded in 1994 by the chemical industry, for the chemical industry, and has steadily grown stronger over the years. CDI serves CDI's members and provides their inspection and audit needs in order to provide them with cost-effective risk assessment systems using the best chemical and LPG knowledge available.
CDI Marine

Society of International Gas Tanker and Terminal Operators (SIGTTO)

The purpose of this organisation is to promote safe, environmentally responsible and reliable liquid gas transport and terminal operations. To fulfil this mission, the association is engaged in proactively developing best operational practices and guidelines, sharing lessons learned, promoting training and development for everyone within the sector, fostering mutually beneficial relationships with regulators and other stakeholders, and conducting business with professionalism and integrity.
Home | SIGTTO - The Society of International Gas Tanker and Terminal Operators

About Antea Group

Antea Group is home to 1,800 proud engineers and consultants. Together, we build a safe, healthy and future-proof living environment every day. You will find the very best subject specialists in the Netherlands here, as well as innovative solutions in the field of data, sensing and IT. This way we contribute to the development of infrastructure, residential areas or water works. We also contribute to issues concerning climate adaptation, the energy transition and the replacement challenge. From research to design, from realisation to management: we bring the right knowledge to the table for every task. We think critically and always from the mindset of going for the best result together. This way, we anticipate today's issues and tomorrow's solutions. Already for 70 years.

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