MAGPIE

SMART GREEN PORTS

Appendix 1

Ammonia Bunkering Demonstration Report

Further details and implementation

APPENDIX 1
AMMONIA BUNKERING
DEMONSTRATION REPORT

FURTHER DETAILS AND IMPLEMENTATION

D5.1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036594.

Appendix 1 is a further elaboration of the main report and is structured around validation sheets, each describing a separate topic.

For each topic, the validation sheet explains how the topic was developed for the pilot, along with the recommendations resulting from the lessons learned during the pilot.

The experiences during the pilot are used to validate the safety framework developed for ammonia bunkering in Rotterdam. In each validation sheet a general part, pilot report and recommendations are shown for the topic, followed by the Rotterdam requirement for safe ammonia bunkering once ammonia fueled vessels and ammonia bunker vessels start their operations in Rotterdam.

The first validation sheet (VS 00) shows the lessons learned from the pilot. The second (VS 01) explains the safety system developed for ammonia bunkering.

Rotterdam used the Port Readiness Level methodology for the preparation for ammonia bunkering and established a safety framework for bunkering based on best practices and experience from LNG bunkering.

The structure of the validation sheets in Appendix 1 follows the relevant topics of the preparation process and reflects all topics of the Safety Framework.

Overview of the topics addressed in the validation sheets

Disclaimer
This report reflects the steps taken in order to perform a ship to ship ammonia bunkering pilot and test and validate the ammonia bunkering safety framework by the Port of Rotterdam, The Maersk Mckinney Moller Center for Zero Carbon Shipping and other parties who have contributed to the activities and this report . Although, the utmost care was taken during the pilot and the validation of the ammonia bunkering safety framework the drafting of the report, including the lessons learned and recommendations, the report is provided "as is", without any representation or warranty, express or implied, including but not limited to any warranty of merchantability, fitness for a particular purpose, accuracy, completeness or sufficiency. Use of the report and recommendations is for your own risk and account. In no event shall the creators and contributors to the report be liable for any direct or indirect, incidental special exemplary, punitive or consequential damages however caused arising out of the use of the report.

The information in the Validation Sheets is based on current (Q1 2026) insights and policies. Always consult the most up-to-date information, regulations and procedures.

Validation Sheet

VS 00 Lessons Learned

General introduction

In the process for the preparation and execution of the ammonia bunker pilot there were three phases: general preparation phase (1), operational preparation phase (2), and execution phase (3) performed in Rotterdam on 12 April 2025, we identified several areas for improvement. These "lessons learned" have led to valuable recommendations for future ammonia bunkering.

This document gives an overview of observations or issues. The lessons learned are based on how the issues were handled. The recommendations provide advice for avoiding issues in the future.

Although it's a long list, safety was never compromised since all the issues were solved before the bunkering took place.

All recommendations will be used as input for the safety, governance and regulatory framework developed for future bunkering of ammonia.

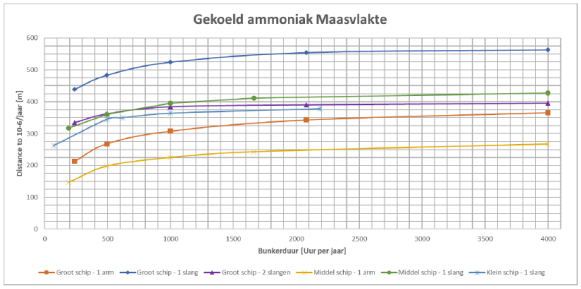
The topics addressed in the lessons learned:

Lessons learned – general preparation phase

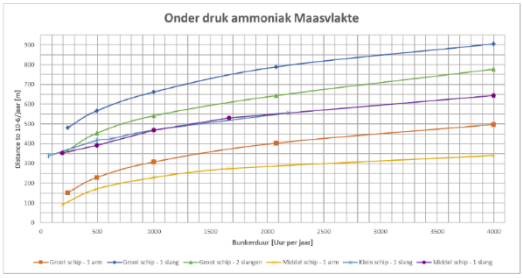
Cold ammonia

Observation

During the general preparation phase the port of Rotterdam performed quantitative risk assessments and dispersion studies. Evident in the results of the studies is the larger risk contour and gas dispersion reach for pressurized ammonia compared to refrigerated cold ammonia. Early in the planning the decision was made to use "Best Available Technology" (BAT) during the pilot. Due to this, the decision was taken that the demo had to be performed with cold ammonia.
The quantitative risk assessment for the also shows the difference in safety distance (10^{-6} contour) in case of a large bunkering. A bunkering with two smaller diameter hoses instead of one large diameter hose for the same amount of transfer gives in modeling a decreased safety distance.



Figuur 0-1: risicoafstanden tot 10^{-6}/jaar als functie van de jaarlijkse bunkerduur voor het bunkeren van gekoeld ammoniak voor alle bunkerscenario's



Figuur 0-2: risicoafstanden tot 10^{-6}/jaar als functie van de jaarlijkse bunkerduur voor het bunkeren van ammoniak onder druk voor alle bunkerscenario's

Lesson Learned

Bunkering of refrigerated cold ammonia (-33° C) instead of pressurized ammonia will lead to smaller restriction areas and smaller safety distances to vulnerable areas which are easier to integrate in the safety systems of the port. However, currently no barges that are certified for cold ammonia were available to participate in the pilot. In Europe transport by inland navigational vessels of ammonia to the hinterland is (still) performed under pressurized condition.

In case of a large scale bunkering the use of two smaller diameter hoses is preferred instead of one large diameter hose.

2.1a: Recommendation
Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (33 °C) for bunkering in port areas instead of pressurized ammonia.
See: VS A, VS F002, VS F008.

2.1b: Recommendation
Stimulate that the transport of ammonia to the Hinterland by inland navigational vessels will be cold ammonia.
See: VS F002, VS F008.

2.1c: Recommendation
Stimulate and support the use of two hoses (and a vapor return hose) for high transfer rates of ammonia instead a transfer with one high diameter hose. (e.g. 2x500 instead of 1x1000 m^3/h). Prohibit transfer rates in one hose above 1000 m^3/h.
See: VS A.

Liability

Observation
For the preparation of the pilot an "Operational Agreement" was arranged between all operational involved parties. In the Operational Agreement a lot of issues were addressed and during the negotiation's liability and the risk of contamination were issues that led to hurdles and discussions.

Lesson learned
During the preparation for a pilot the commercial liability and the liability in case of contamination and an incident are issues that should be addressed in an early stage.

2.2: Recommendation
A Quality Management System (QMS) should be in place to address the risk of contamination during bunkering pilot. All involved parties should have a QMS and during the compatibility assessment arrangements should be established to have, timely and in accordance with the agreed, required specifications for suitable quality and quantity control. In the contracts between de supplier, bunker operator and receiving vessel operator, liability should be addressed
See: VS 01.

Flexibility

Observation
During the planning period toward the bunkering pilot, many changes were made in the participants, vessels and timeline.

Lesson Learned
A pilot is difficult to arrange due to the maritime related commercial dynamics. All involved parties should be aware that a pilot is not a commercial activity with a profit motive, the investment will pay out in future operations.

2.3a Recommendation
2.3.1 If a pilot has a dependency on maritime commercial activities in a port, make sure the execution of the pilot is closely aligned with the commercial operations of the vessels in the port.

2.3b Recommendation
Make sure pilot relevant stakeholders have transparency as timely as possible on objective, planning, responsibilities, competence needed, and flexibility related to a pilot. Also, on the budget needed for the pilot and are willing and see the benefit for investment in the future.

Adapting an LNG bunker vessel for ammonia bunkering

Observation
No inland navigational vessels are currently available for the transport of cold ammonia. As an alternative we looked into the feasibility to use an inland navigational LNG bunker vessel already ammonia ready equipped.

Lesson Learned
Although from a technical point of view, an ammonia ready LNG bunker vessel is 95% suitable for ammonia bunkering, it's challenging and very costly to get to 100% suitability and get the proper certification in short term. Due to the fact that the vessel carried LNG before, this increased the risk of contamination.

2.4a Recommendation
Be aware that for the use of an LNG bunker vessel as ammonia bunker vessel, time and investment is needed to do the preparation for 100% pilot suitability of the LNG bunker vessel. Aspects of importance are:
(1) bringing a dedicated bunker tank under ammonia atmosphere taking into account possible methane and nitrogen (used for purging) contamination with ammonia
(2) also purging with nitrogen after the operation requires attention to make sure that there will not be contamination of ammonia with nitrogen in the bunker tank or cargo tank of the bunker vessel.
(3) Nitrogen in an ammonia bunker tank or ammonia cargo tank will affect the boil off gas management system due to the impact of nitrogen on compression equipment.
See: VS A, VS F006

Lessons learned - operational preparation phase

Agility and resilience

Observation
Many changes were made in the last two months before the pilot which requested flexibility from all partners (see also recommendation 2.3).

Lesson Learned
Shipping is dynamic. Nomination of vessels is done on short term and changing circumstances require last moment adjustments. The flexibility of all members of the Pilot workgroups was really challenged. Avoiding last moment changes was difficult, for example, you have to rearrange due to a cargo related commercial issue. Working with deadlines was very challenging also due to dependency of preparedness between the Pilot workgroups.

3.1 Recommendation
In the dynamics of shipping, last moment changes are unavoidable. Ensure that the pilot workgroup members, related stakeholders and decisionmakers are informed on the dynamics with the related challenges to demonstrate sufficient agility and resilience in the preparation of the pilot.
See: VS I

Communication

Observation
Some pilot workgroup members felt they had been informed relatively late and lacked a clear overall picture. As a result, they sometimes did not feel comfortable with the overall project. Also, some members gave the signal it was difficult to inform on short term their internal company management and other relevant colleagues.

Lesson Learned:
Timely and transparent communication is very important. It remains challenging and time consuming.

3.2 Recommendation
Communicate as timely and transparent as possible even if there is no specific update. Make sure that also overall information is shared within the specific WGs to make sure there is comfort that all aspects are being taken care off.
See: VS I

Evacuation routes on board

Observation

Before the pilot started no second evacuation way was available on the outer vessel. An evacuation route from the Oceanic Moon was established by lowering the gangway to the waterside.

Lesson Learned

Make sure there are always two means of escape or evacuation available for the people on board of the vessels. A pilot ladder is often installed in the cargo area and due to this less suitable as a means of escape.

3.3 Recommendation
Establish two exit/evacuation routes or ways of escape on board of the vessels. Include the information in the JPO and make sure everybody is aware of the means for evacuation.
See: VS F004, F006, F011.

Evacuation routes on shore

Observation

Initially on the shore side there was only one entrance route (and exit) available. By providing a second gate at the terminal a second entry/escape route was established.

Lesson Learned

Important for evacuation as well for safe deployment of the fire brigade two routes for entrance and exit/escape are required. They are also needed to give the possibility to the fire brigade to enter an effect area in two ways, they will use the proper entrance based on wind direction to avoid they have to pass through the plume.

3.4 Recommendation
Make sure there are always two means of entrance and exit for the emergency response services and two ways of escape for the evacuation of personnel on/via the shore.
See: VS F004, F011.

Incident response preparedness vessels-shore

Observation
Incident response on the shore side should have information on the incident response capabilities of the vessels.

Lesson Learned
To develop a good emergency response plan for the pilot it is essential to have the input from the involved parties, vessel, the terminal and shore emergency response organization on capabilities and equipment.

3.5 Recommendation
Since all efforts in preparing the barriers for the right side of the Bow Tie is done in three phases, first response by the vessels, second response by the terminal and third response by the shore incident response organization, exchange of each other's capabilities and equipment is essential.
See: VS F004, F011

Awareness on safety procedures

Observation
Before the operation started some internal personal of the terminal and service providers were not sufficient informed on restrictions and procedures.

Lesson Learned
Although all relevant communication for the pilot was prepared and executed, at the time the pilot should start some people weren't sufficiently informed. We learned that a second check – with main focus on operation relevant requirements and agreements - should be done before the start of the pilot to see if all relevant people are aware of the agreed procedures and restrictions.

3.6 Recommendation
Ensure all relevant personnel, service providers or other third parties are informed upon restrictions and procedures.
See: VS D, E, F003, F004,

Operational reporting during the pilot

Observation
All people who were operational involved in the operation were informed on when the operation would take place. However, people standby on the shore based on the timeline of the pilot, like the Emergency response officers weren't informed during the pilot on the progress during the pilot.

Lesson Learned
Organize reporting of progress of the operational pilot to parties not directly involved in the operational operation though have a responsibility during the pilot. Define agreed moments to report such as:

- the arrival of the vessels
- start of the connection
- start of transfer
- end of transfer
- end of purging
- end of operation

3.7 Recommendation
Make sure all relevant organizations and Operational Managers remain informed on the progress on agreed moments and agreed way during the pilot.
See: VS F004

Lessons learned during the pilot execution phase

Training and competence

Observation
During the pilot the crew on board of the vessels are ample experienced in loading and unloading of ammonia at ammonia terminals. However, there was no experience with ship-to-ship transfer of ammonia and no knowledge on requirements for a transfer at another location than an ammonia terminal. A service provider (Fendercare) was on board with STS experienced operators to facilitate and support the pilot operation.
Competence of the STS service provider is focused on the safe transfer of the ammonia, However, they are not experienced in in-port bunkering with the local specific requirements such as control zones, SIMOPS, terminal readiness.

Lesson Learned
Present training and competence of seafarers on ammonia tankers for ship-to-ship operations or ammonia bunker operations in a port is insufficient for future bunker operations. Although STS service providers will be superintending the STS bunker operation in case a non-licensed bunker vessel, the knowledge on in-port bunkering and specific port requirements still can be insufficiently due to a lack of knowledge by the superintendent and crew on port specific issues.

4.1a Recommendation
When a non-adapted and non-licensed LPG carrier is used for an ammonia bunkering supervision is needed for which external, experienced and competent service providers are mandatory to provide supervision on board. The supervisor should specifically be aware of in-port bunkering and specific local regulations and requirements for in-port operations such as control zones, and other operational aspects, or should manage the needed relevant knowledge and expertise.
See: VS 02, A, E, F006

4.1b Recommendation
When a, for bunkering equipped and adapted LPG carrier is used on a regular base as an ammonia bunker vessel, crew needs to be experienced, competent and aware of specific local regulations and requirements for in-port operations such as control zones, Simultaneous Operations (SIMOPS) and other operational aspects. If knowledge on specific local regulations and requirements for in-port operations is missing, the bunkering should be supervised by an experienced and competent external supervisor
See: VS 02, A, E

4.1c Recommendation
For licensed and dedicated ammonia bunker vessels used for ammonia bunkering in a port, it is essential to ensure – which is being assessed during the audit for the licensing process - procedures are in place to assure personnel involved possess the necessary competence, knowledge and awareness on in-port operations, local regulations, and specific aspects of in-port bunkering, such as control zones, Simultaneous Operations (SIMOPS) and other operational aspects.
See: VS 02, A, E

4.1d Recommendation
Stimulate training and competence on non-terminal related in-port operations for crew on board of ammonia fueled vessels.
See: VS 02

4.1e Recommendation
Develop training and competence requirements for crew on board of future dedicated ammonia bunker vessels with focus on local regulations and in-port bunker operation specific issues such as control zones, Simultaneous Operations (SIMOPS) etc.
See: VS 02

Operational measurement of ammonia before disconnection

Observation

During the pilot a lack of portable ammonia gas measurement equipment occurred for operational testing. Gas detection tubes are not sufficient to test the concentration of remaining ammonia gas in the lines after purging.

Lesson Learned

Standard portable measurement equipment on board of an LPG carrier carrying ammonia is not sufficient for an STS operation or bunker operation where hoses have to be purged. The gas portable gas measurement equipment should be usable to measure the remaining concentration in the line via alternative sampling points (drains). Standard gas sampling points were not available. Agreements on the max ppm level of ammonia after purging needs to be known form the JPO to all relevant crew members.

4.2a Recommendation
Make sure that for in-port operations appropriate, sufficient, calibrated, tested and operational monitoring/detection equipment/systems are available on board of both involved vessels.
See: VS C, F006

4.2b Recommendation
Address to IMO and OCIMF that the appropriate monitoring/detection equipment needs to be on board at the right places.
See: VS F006

Compatibility check of the hose

Observation

During the pilot it was observed by the STS service provider that the liquid line (loading hose) – already connected - was certified for LNG transfers and not for ammonia/LPG. The LNG certified hose can't be used for the temperature range we expect to work in (-40 C till 40 C) The STS service provider manager arranged an LPG certified hose was brought on board to replace the LNG hose. This delayed the pilot.

Lesson Learned

During the compatibility assessment operations hoses and hose certificates should be checked thoroughly. Hoses should be suitable for the products to transfer. In the QSM system of the bunker operator (or for the pilot, the service provider) procedures should be in place to assure that hoses will be completely clean and dry because it could impact on ammonia quality.
All the equipment to be used needs to be checked on suitability for the ammonia bunkering before bringing the equipment on the vessel

Recommendation 4.3a
Implement in the Safety Management System (SMS) that all equipment to be used for bunkering needs to be certified for ammonia and checked on certification before transfer to the vessel.
See: VS C, F006, F008

Recommendation 4.3b
Address hoses, the suitability of the hose, hose certificates and test log during the compatibility assessment on forehand of the operation.
See: VS C, F008

Recommendation 4.3c
Have a final check on the suitability of the equipment before transfer on the vessel.
See: VS C, E, F008

Pressure testing of the hoses

Observation
The newly delivered LPG hose to the vessel existed out of 2 smaller hoses with a flange connection in the middle. The flange connection was situated in between both vessels just above the waterline. There was no way this connection could have been pressure tested with soap.

Lesson learned
The hoses to be used for bunkering should not be too long, preferable it should be one hose. Pressure testing should be possible.

Recommendation 4.4
Make sure that the length needed for the transfer hoses is such that no flange connections need to be used, and pressure testing is possible.
See: VS F008

Flowrate monitoring

Observation
It was not possible to see and therefore monitor the flowrate of the vessels.

Lesson learned
It should be possible to monitor the flowrate, because of safety, on what has agreed in the JPBO and know the time needed for the transfer.

4.5 Recommendation
Make sure that monitoring of the flowrate is possible
See: VS F008

Accepted maximum concentration in the line before disconnection

Observation

During the pilot there was discussion on the acceptable maximum concentration remaining in the line before disconnection. During the pilot there was a limited experience with purging by the crew of the vessels.
In-port requirements are due to the low odor threshold lower than the acceptable limit for safety.

During the pilot the maximum concentration was set on 200 ppm. This is close to the Dutch Intervention value "alarm threshold" of 198 ppm with exposure duration 60 min. This is comparable with the US AEGL 2 220 ppm with exposure duration 30 min.

The SGMF states the recommendation of 25 ppm "*Purging/inerting is considered achieved when sampling at the furthest end from the nitrogen injection point measures no more than 25ppm (0.0025% vol) Ammonia*".

Lesson Learned

In the JP(BO) for the pilot the maximum ammonia concentration was set on 200ppm. It was learned that it is a low concentration difficult to reach and difficult to measure. Purging with hot ammonia gas, target temperature as set in the JPBO, was a very important step in the ammonia-freeing process before purging with nitrogen.

N2 purging needs the right equipment and capacity onboard during the pilot.

4.6a Recommendation
Incorporate into the purging procedure the recommendation of hot gassing with ammonia including the appropriate requirements to be agreed upon in the JPBO.
See VS D, F008

4.6b Recommendation
Standardize for in-port operations the acceptable maximum remaining concentration after purging before disconnection in the ammonia bunker transfer line and vapour return line (if used) on max 25 PPM measured at the furthest end from the nitrogen injection point, to avoid hindrance or smell due to the low odor
. See VS D, F008

4.6c Recommendation
Consider to incorporate in the purging standard an additional time-period on the remaining concentration of one minute, to be checked by a second measuring after a minute. More guidance is needed on top of the IMO MSC1- circ 1687 8.5.9.
See VS F008

4.6.d Recommendation
Recommend and support adjustment of the MO MSC1- circ 1687 8.5.9. with:

- *Hot gassing*
- *Maximum remaining concentration before disconnection*
- *Method of measuring the remaining concentration before disconnection*

See VS F008

Drip tray

Observation

During the pilot before connection of the transfer line the drip tray contained a layer of water, and the drip tray was partly covered with plastic blankets. After removal of the plastic seals, (reason why they were there is unclear) the port authority ordered to drain the water till the drip tray was dry.

Note:

- Small, spilled droplets would solve in the water, however, for larger spills, water in the drip tray will cause increased evaporation.
- Contaminated water should be contained and processed
- Water in the drip tray will reduce the capacity of the drip tray for containment of a spill

Lesson Learned

A drip tray should be inspected before commencing the connection, water should be drained. The drip tray should be empty, ready for use and cover all possible leak sources.

4.7.a Recommendation
The drip tray should be empty, ready for use before commencing the connection of the ammonia transfer hose.
See VS F008

Observation

The drip tray at non adapted LPG carriers is dimensioned for covering the area underneath loading and unloading equipment of the terminal connected to the manifold. In case additional equipment is connected to act as an ammonia bunker vessel, e.g. PERC, insulation flange, hose flange connection or QCDC, etc., a part of the connections extends beyond the drip tray which in a case of leakage can result in uncontained liquid ammonia on deck.

Lesson Learned

After connection of the hoses and additional equipment installed at the manifold e.g. (P)ERC, it was considered that the dimensions of the drip tray did not fit. The drip tray didn't cover all area underneath the connections at the manifold.

4.7 b. Recommendation
The drip tray shall be sized and positioned to fully cover the area beneath all manifolds pipe or hose connections, with no components protruding beyond its perimeter."
See: VS F006, F008

Contaminated of contaminated water

Observation

During the pilot there were no other means to empty the drip tray other than draining it on deck. From a port perspective we require that no water contaminated with ammonia will be drained overboard. If during a rainy-day water accumulates in the drip tray, vapour can be absorbed into the water due to the hygroscopic properties of ammonia. The water gets contaminated with ammonia, and it's not allowed to drain this contaminated water overboard in a port.

IMO MSC1-circ 1687 gives as functional requirement:

5.9.4 Each tray should be fitted with a drain valve to enable water to be drained over the ship's side where the tray is installed in a location where water may be retained.

5.9.6 Drip trays should be provided with means to safely drain or transfer spills that contain ammonia to be contained or treated.
The guidance from SGMF gives clear recommendations *"Equipment should be in place to empty spilled liquid ammonia from the drip tray into a knock out tank or drum to avoid uncontrolled evaporation with emission"*

Lesson Learned

Construction and functional requirements for the drip tray for draining contaminated water are not yet in line with the environmental and safety policy of the Port of Rotterdam.

4.8a Recommendation
For in-port bunker operations the involved vessels should be equipped with means to avoid the discharge of ammonia contaminated water from e.g. drip trays or deck into the harbor water.
See: VS F006, F008

Containment of spilled ammonia.

Observation

During the pilot there were no other means to empty the drip tray other than draining it on deck. In case of a larger spill, the drip tray will contain "cold cooking" very slow evaporating liquid ammonia. It will be a long remaining source of low concentration emission. Draining the content on deck and flushing it overboard into the harbour water will lead to large emissions and safety issues. Within the port it is prohibited for environmental and safety reasons, and it can lead to hindrance or smell complains.

Lesson Learned

Construction and functional requirements for the drip tray for draining contained spills of cold cooking ammonia are not yet in line with the environmental and safety policy of the Port of Rotterdam.

4.9a Recommendation
LPG carriers: For in-port bunker operations using non-adapted LPG carriers as ammonia bunker vessel, a system needs to be foreseen – could be modular equipment or knock out drum/tank – where the content of the drip tray should be contained
LPG carriers that are adapted and dedicated for ammonia bunkering should include a retainment or treatment system in their design with the retrofit
See: VS F006, F008

4.9b Recommendation
On both in the ammonia bunkering involved vessels, installed equipment should be in place to empty spilled liquid ammonia from the drip tray into a containment or treatment system e.g. a knock out tank or drums, to avoid uncontrolled evaporation with emission.
Drip trays should have a draining and overflow system so that in case of leakage the ammonia is released into this containment system.
See: VS F006, F008

Joint Plan of Bunker Operations JP(B)O

Observation
During the pre-operation meeting, a discussion started on pumping rates, the volume to be transferred, and other parameters of the transfer.
In the phase of the bunker process where the transfer line was purged with hot ammonia gas (see also 4.6), although the JPO stated the maximum temperature should be 40°C, discussion and confusion arose on the agreed temperature on both sides of the transfer hose required for proper hot gassing.

Lesson Learned
Although transfer parameters and operational parameters are prescribed in the JPBO, discussion can raise on these issues during the pre-operation meeting. It's preferable when a Person in Charge (PIC) experience a lack of experience with the crew, the PIC have to update the crew with relevant information on fore hand, before the start of the pre-operation meeting. Unclear or missing issues in the JPBO should be addressed and corrected by the PIC on forehand to avoid discussion during the pre-operation meeting.

4.10a Recommendation

- *The operation shall be performed in compliance with the JPBO, and applicable instructions and these requirements should be known by all relevant crew members.*
- *All relevant people should participate in the pre-operation meeting.*
- *Address during the pre-operation meeting:*
- *all transfer and purging parameters agreed upon in the preparation phase*
- *location specific items and topics relevant for in-port ammonia bunkering.*
- *The PIC of both vessels is responsible for ensuring that all relevant crew members are aware of these parameters.*

See: VS D, E, F008

Length of the transfer hose

Observation

During the pilot the LPG hose used for the ammonia transfer existed out of two smaller hoses with a flange connection in the middle. The flange connection was situated in between both vessels in the lower U bend just above the waterline. There was no way this connection could've been leak tested with soap during the pressure test.

Lesson Learned

Connections where possible leakage can occur (and a connection in a bend of a hose is certainly one of them) should be accessible to do a leak test.

4.11a Recommendation

Use a "one length" hose instead of two connected hoses for the bunkering of ammonia. In case more connected hoses have to be uses, make sure the connections can be leak tested before the start of the bunkering.

See: VS F008

Firefighting systems – liquid ammonia spill

Observation

Before the connection, vessels crew lined up the vessels firefighting system conform SOLAS, including the dry powder extinguishing system. However, for ammonia spills and emissions the SOLAS required equipment's is not the most effective incident response equipment. Before the pilot, Port of Rotterdam request the vessels to have the sprinkler system above the manifold of both vessels ready for immediate use. This could also help to limit the amount of ammonia gas that would spread in case of leakage. However, if the sprinkler system also reduces the capacity of the driptray and lead to flushing overboard of in the

drip tray contained spilled liquid ammonia, or flushing overboard of ammonia contaminated water, this is not in line the environmental policy of the port.
Note:
Water can absorb ammonia vapors during a gas leak, but if the release is large or water is insufficient, vapors may still pass through and expose people downwind. The water used becomes contaminated and turns into a corrosive liquid (ammonium hydroxide), which continues to release ammonia. If not contained properly, it can spread and pose further risks. It must also not flow back to the leak source. Responders should be well-trained to assess wind direction and approach to avoid chemical burns.

Water applied directly to liquid ammonia should be avoided

Lessons Learned

It is not sure if foam of powder systems is suitable for incidents with liquid ammonia. LPG tankers used as ammonia bunker vessel might not be optimal equipped for dealing with a liquid ammonia releases or spills
The location of the sprinkler, water curtain or water wall is very important. Well located and well-designed sprinklers, water curtain or water walls can protect crew members from potential exposure though should not require intervention from the crew. An option might be a remotely operated system.

4.12a Recommendation
Get knowledge from the Ammonia industry on best practice emergency response in case of a liquid ammonia leakage on board of vessels.
Supply dedicated ammonia bunker vessels with proper and suitable equipment for repression of liquid ammonia releases.
See: VS F011

Simultaneous Operations (SIMOPS)

Observation

During the ammonia transfer a surveyor came on board, visiting the vessel. The work being done by the Surveyor is a simultaneous activity. It needs to be clear and clearly communicated what is allowed and who is responsible for a simultaneous operation or activity. If SIMOPS is requested a risk analysis needs to be there to show what simultaneous operations are acceptable during the bunkering. It needs to be clear and clearly communicated what is allowed and who is responsible for that.

Lesson Learned:
SIMOPS should be controlled. Activities that are "common" including survey work is also a part of the SIMOPS management. SIMOPS should be addressed in the JP(B)O

4.13a Recommendation
Address all expected SIMOPS in the J(B)PO. Make clear what the responsibilities and conditions and restriction are for simultaneous operations.
See: VS F009

Fatigue management

Observation
The pilot took more time than foreseen, and availability of competent people was needed during the full timeframe. This resulted in people who were on shift much longer than acceptable.

Lesson Learned
Operations can unforeseen take longer than expected. If safety and progress of the operation is depending on a small number of specialists, it can introduce the risks involved with fatigue. When preparing the operation, it is important that enough experts are available to make it possible to work in shifts.

4.14 Recommendation
Perform Fatigue management, make sure on forehand that the risk of fatigue can be managed if the operation takes more time than foreseen. Single competence to be avoided. Training of crew needed to have more than single competence. Superintendents from the Port and the other experts should be able to take shifts and/or have the possibility for replacement.

Powered Emergency Release coupling (PERC)

Observation
During the pilot a modular PERC system (KLAW) was used and brought on board existing of four saddles, a hydraulic powered PERC (HPU), a pneumatic powered hydraulic system, a vessel separation detection device to activate the PERC, and a filter for filtering the pressured air of the vessel that is used for powering the hydraulic set.
A large and heavy modular PERC installation, such as used for STS transfer at sea, is difficult to place in the neighborhood of the manifold. The handling of the installation has to be done be external specialists (superintendents) since the crew is not instructed or experienced in handling the installation.
The used PERC system operates independent of the vessels ESD system. There was no connection between the vessels ESD system and the modular PERC system. In case of an activation of the vessel separation detection device, before it triggers the automatic

release, an alarm signal will sound, and a visible sign will be raised. The ESD of the vessel have to be activated manual based on the alarm and raised sign.

Present PERC are constructed in a way the valves on both sides of the separation flange closes mechanically due to the separation. Best available technology is a PERC construction that close the valves and purged the separation part before separation to minimize the emission when a separation occurs.

Lesson learned

The Klaw LNG system (similar to alternatives from Manntek) presents logistical challenges due to its size and complexity for use on routine bunkering operations.

Due to the lack of a connection between the modular system and vessel's ESD, current available modular emergency release couplings sets are not ideally suited for routine deployment to ammonia bunkering operations.

4.15 a Recommendation
Develop modular VSD / PERC systems of a more compact design. For the time non adapted, non-dedicated LPG tankers will be used for ammonia bunkering, these systems will be mandatory to use for in-port bunker operations. d for the delivery of ammonia bunkers.
See: VS F006

4.15 b Recommendation
For the time non adapted LPG tankers will be used for ammonia bunkering, means should be developed to make a connection between the modular independent VSD / PERC system and vessel's ESD system.
See: VS F006

4.15 c Recommendation
For the time adapted and dedicated LPG tankers, or dedicated ammonia bunker vessels will be used for ammonia bunkering, the vessel separation device and PERC should be (semi) integrated in the vessel's permanent equipment including a (minimal) ESD1 and ESD 2 system.
See: VS F006

4.15 d Recommendation
Use the latest and best available technology when installing VSD / PERC systems
See: VS F006

Purging

Observation
After the hot gassing to remove the liquid ammonia from the line, the vessels purged with nitrogen towards an empty deck tank.

During the pilot a 22m 8-inch liquid hose was utilized. To effectively remove liquid and purge the hose, it took more than 6 hours. During the hot gassing, only one side reached the target temp. Liquid ammonia from the vessel lines was escaping back into the hose catenary, reducing the effectiveness of hot gassing efforts.

Crew working aboard ammonia tankers, are not regularly exposed to operations utilizing flexible cargo hoses, meaning that they do not have regular experience of the process required for clearing the hose of residual ammonia

Lesson learned
Liquid hose clearing to remove ammonia to 200 ppm levels can be a significantly time-consuming task, heavily influenced by hose length and crew familiarity with this process.

4.16a Recommendation
Develop proper purging procedures and Ammonia Release Mitigation Systems to establish purging without emission.
See: VS F006, F008

4.16b Recommendation
For process efficiency the parameters for hot gas temperature should be clearly defined for both vessels. It is important that the supplying vessel understands that the reference temperature used to determine when to cease the warm-up process should be taken from the receiving vessel's readings, not from the manifold temperature of the supplying ship.
See: VS F006, F008

4.16c Recommendation
The use of a QCDC or end valve at the receiving manifold could remove the necessity for complete line clearance. Similarly, shorter or lesser diameter liquid hoses would hasten the purging process.
See: VS F006, F008

Nitrogen supply

Observation
A significant quantity of nitrogen was required to purge the liquid hose upon completion. Together with the nitrogen, cargo vapours were collected in the deck tank of the Oceanic Moon. The vapours could not be combusted and rather had to be held for later venting at sea. There was no nitrogen generator on board or nitrogen tank available on board of the vessels. The nitrogen was supplied by a cylinder rack with nitrogen bottles.

Lesson Learned

LPG tankers, bunker vessels, and future ammonia fueled vessel Not all LPG tankers have a nitrogen generator and storage on board of the vessel.

4.20a Recommendation

Consideration should be given to permitting the purging of liquid hoses (following hot gassing) with air, thus allowing the ammonia/air blend to pass through the vessel GCU. In order to control the flammability hazard introduced thereafter, the ammonia free/air purged hose should be purged and vented to atmosphere with nitrogen/inert gas prior to hose disconnection.

See: VS F006, F008

4.20b Recommendation

Future dedicated bunker vessels should be equipped with a nitrogen generator and storage

See: VS F006, F008

4.20c Recommendation

Future bunker vessels should be equipped with an ammonia release mitigation system

See: VS F006, F008

Validation Sheet

VS 01 Port Readiness Level & Safety Framework

General

This validation sheet highlights two important frameworks that are used for the preparation of the port of Rotterdam for ammonia fueled vessels.

1. The Port Readiness Level (PRL) tool of the International Association of Ports and Harbors which provides an overall structure and framework.
2. The Rotterdam safety framework for ammonia, which has been established as a part of the Rotterdam preparation for the future with ammonia fueled vessels and is one of the tasks that are defined in level five of the PRL tool.

Port Readiness level

The Port Readiness Level for Marine Fuels (PRL-MF) assessment tool:

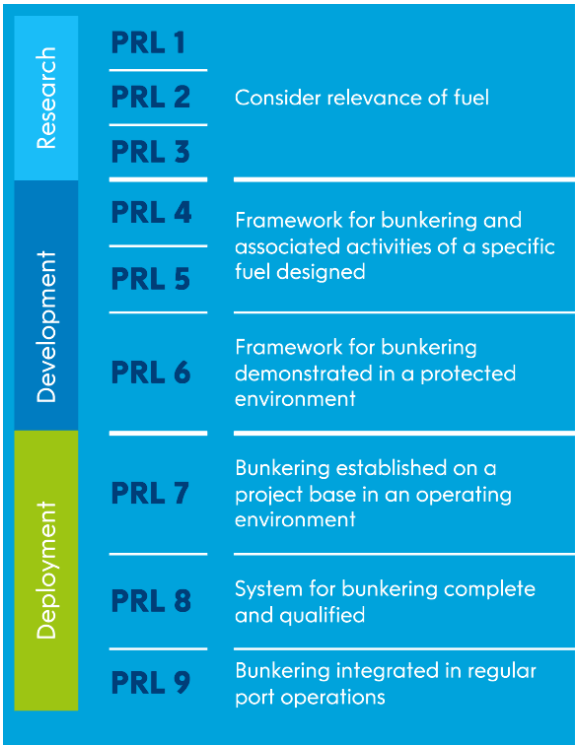
Source: Port Readiness Level for Marine Fuels (PRL-MF) | Port Readiness Level and Products | IAPH

The Port Readiness Level for Marine Fuels (PRL-MF) assessment tool is an assessment framework that ports can use to self-assess their readiness and identify areas requiring further development to facilitate bunkering of a new low- or zero-carbon marine fuel.

It includes a list of assessment criteria with guiding information to support port efforts across research, development, and deployment phases. The PRL-MF consists of nine readiness levels—largely following the schematic of the NASA Technical Readiness Level (TRL). The first three levels concern the research phase, the next three levels address the development phase, and the last three levels speak to the deployment phase:

- Research Phase (PRL-MFs 1-3): The goal of the research phase is to determine the relevancy of the fuel for the port and its stakeholders. This phase will help to identify information gaps, determine pros and cons, and ascertain the interest of port stakeholders.
- Development Phase (PRL-MFs 4-6): The goal of the development phase is to make strategic decisions about implementation, create a guiding framework based on assessments and testing, and run a pilot test for the target fuel.
- Deployment Phase (PRL-MFs 7-9): This phase includes scaling-up operations, beginning with a project-based approach and growing into a systems approach that will create a regular port operation.

Each readiness level contains a list of strategies and tasks to be completed to get prepared. By examining the tasks required for each readiness level, ports can create a practical roadmap and timeline of the port ambitions. This information, along with the current port readiness level, can be made publicly available so that stakeholders can make informed decisions when investing in fuel production, ships, equipment, planning, routes, green corridors, and more.



Each of the nine levels has an objective that can be achieved by completing strategies, tasks and measures within the level.

The strategies, tasks and measures are plans and actions to be performed by appropriate stakeholders in the port community.

The optional tasks and recommendation are meant to create structures of support of the port community.

- It is possible to work in multiple levels at the same time.
- Not all strategies tasks and measures will apply to all ports.

The Port Readiness Level for Marine Fuels (PRL-MF) tool is a fuel-agnostic tool which is free to use for IAPH members only: https://www.iaphworldports.org/products/

Rotterdam Safety Framework

The Rotterdam Safety Framework is a structured approach to assure an ammonia bunker operation will be executed conform the safety standards set by the Port of Rotterdam. The Safety Framework consists of 11 topics that need to be checked and fulfilled before or during a bunker operation:

1. Governance
2. Port resilience and Emergency Response
3. External safety
4. Control zones
5. Terminal preparation
6. Nautical safety
7. Vessel(s) safety
8. Mooring safety
9. Bunker safety
10. SIMOPS safety
11. Operational safety

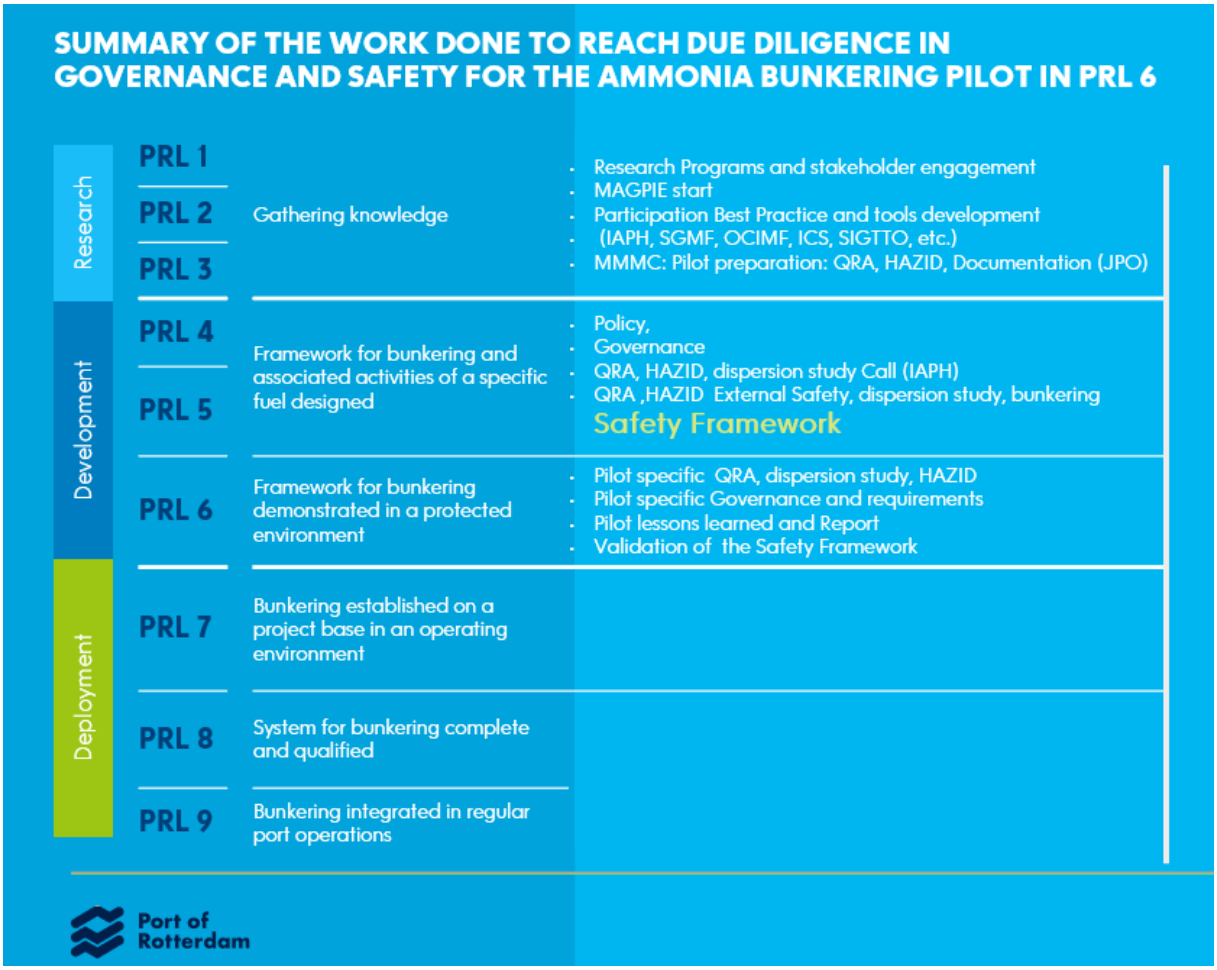
Due diligence in governance:

If all topics of the Safety Framework are adequately fulfilled for a specific bunker operation, the required "license to operate safety level" is achieved.

Port Readiness Level 1 to 5 (PRL 1-5)

The preparation of the Port of Rotterdam for ammonia fueled vessels and the bunkering of ammonia already started in 2020.

The below schedule gives an insight into the activities performed due to the overall preparation that are related to the pilot. Most of the preparatory activities in PRL level 1 till 5 are described in the validation sheets, however since the validation sheets are reporting on the pilot, they will not be complete in showing all activities performed by the POR for preparing for the future with ammonia fueled vessels and bunkering of ammonia.



- In PRL level 1 to 3, the Port of Rotterdam Authority participated in several international research programs and development of best practice and tools. We gained insight into the market and developments and actively assessed stakeholder interests.
- The MAGPIE program started with a first quantitative risk assessment (QRA), Hazards Identification (HAZID) and a format of a Joint plan of operation (JPO) initiated by Port of Rotterdam Authority and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping.
- In PRL level 3, GAPS were identified, and Port of Rotterdam Authority developed a policy and governance road plan in level four for ammonia fueled vessels for execution in level 5.

- The Port Bye Laws were adapted for ammonia bunkering in 2020 to establish a regulatory framework to control ammonia bunker operations.
- The adaptation of the safety framework, that already was in place for LNG and methanol bunkering, to an ammonia safety framework was performed in 2022.
- DNV performed a BOWTIE HAZID and dispersion study for the call of an ammonia fueled vessel and for ship- to ship bunkering a Quantitative Risk Assessment and HAZID study to initiate a Rotterdam bunker map for ammonia bunkering.

The safety requirements for ammonia bunkering in the Port Bye Laws and Safety Framework (PRL 5) are based on the preparatory work done in the level 1 up to and including level 5 and reflect the best practice guidelines of the industry as well as the guidelines of EMSA, SGMF and IAPH, ICS, OCIMF and SIGTTO.

Pilot - PRL 6

In PRL 1 to 5 the Port of Rotterdam prepared itself for the call of ammonia fueled vessels and the bunkering of ammonia. In level 6, in addition to the regular preparation, some pilot specific issues had to be addressed including a pilot specific external safety study to assure sufficient safety distance to vulnerable objects, a gas dispersion study to establish control zones and a HAZID to define necessary risk mitigation. In addition, for governance additional tasks were performed:

- Informing all parties
- Special exemptions
- Shielded and safe location
- Development of pilot procedures
- Proper pilot equipment
- Proper supervision
- Restriction zones for other vessels and people on the shore
- Pilot Emergency response protocol

Pilot recommendations

2.2: Recommendation

A Quality Management System (QMS) should be in place to address the risk of contamination during bunkering pilot. All involved parties should have a QMS and during the compatibility assessment arrangements should be established to have, timely and in accordance with the agreed, required specifications for suitable quality and quantity control. In the contracts between de supplier, bunker operator and receiving vessel operator, liability should be addressed.

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment - PRL 7

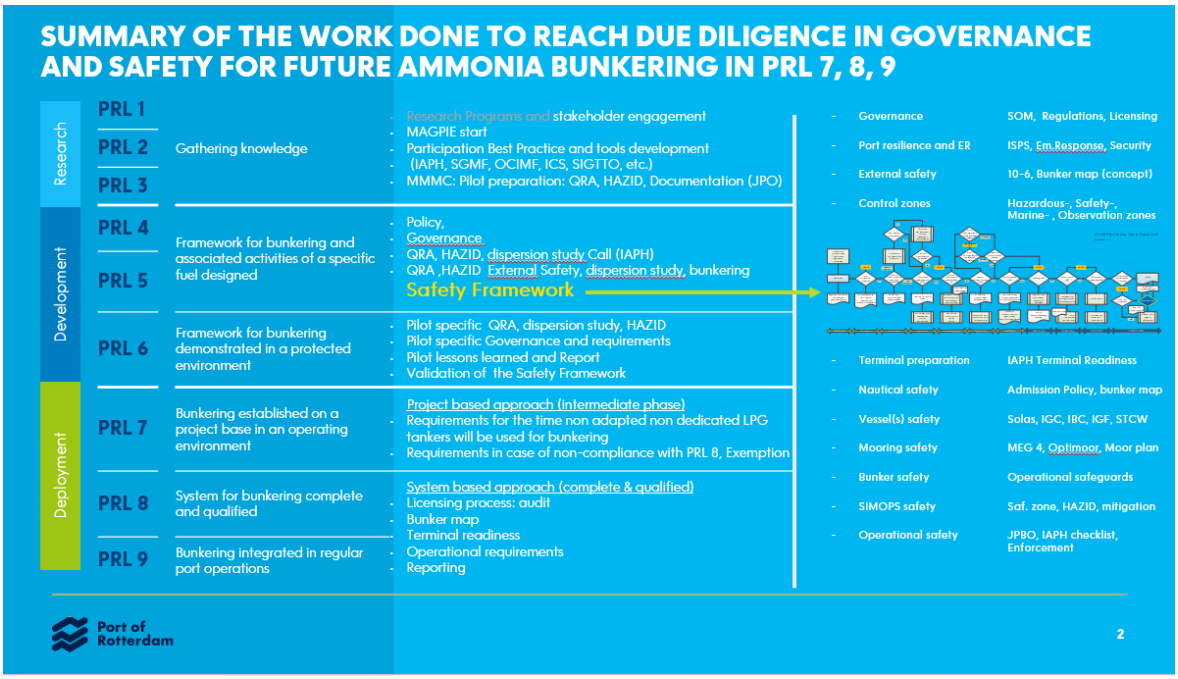
As long as there are no dedicated bunkering solutions available that can obtain a bunkering license, think of the use of non-adapted non-dedicated LPG tankers for bunkering, a project-based approach is used with specific safety requirements and the use of international developed instruments such as the ammonia bunker checklist A of the IAPH.

The project-based approach is also the fallback scenario in case of non-compliance with PRL 8 requirements.

Deployment - PRL 8 and 9

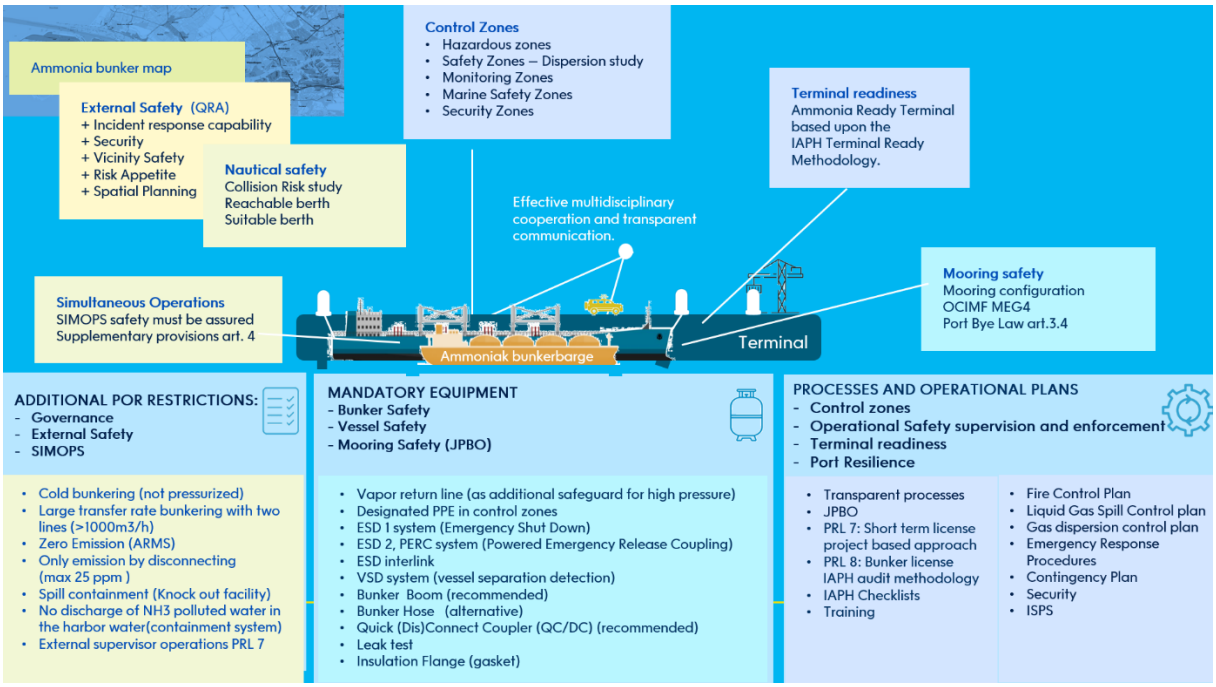
Once dedicated, properly equipped, ammonia bunker vessels are introduced, a system-based approach will be used including the validated safety framework and requirements for bunkering with audited bunker operators and licensed dedicated ammonia bunker vessels. The bunker vessels are licensed to operate on locations that are marked on the POR ammonia bunker map as suitable for bunkering. A second requirement is the preparedness of the terminal for ammonia bunkering alongside the terminal. The port of Rotterdam authority is using international developed tools such as:

- the IAPH audit tool to assure a bunker operator is qualified for safe bunkering
- the IAPH terminal readiness methodology to assure a terminal is properly prepared
- the IAPH ammonia bunker checklists to assure operational safety during bunkering



Safety requirements in PRL 7, 8 and 9

The lessons learned by the MAGPIE Pilot and the validation of the safety framework, are the basis for the safety requirements for future ammonia bunkering in the port of Rotterdam.



This infographic gives a summary, more info can be read in the validation sheets.

Validation Sheet

VS 02 Pre-operation management (PRL 1-5)

This validation sheet is part of the MAGPIE ammonia pilot report. It's built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

This validation sheet highlights the pre-operation management performed to prepare the involved vessels and the port of Rotterdam for the ammonia bunker pilot.

Pilot; PRL 6

This sheet looks into all the necessary actions for the pre-operation of the pilot including relevant pilot specific HAZID/HAZOPS

The Operational Bunker Team was responsible for execution of the pilot pre-operation preparation. The operational bunker team consisted of:

- KSS
- OCI
- Port of Rotterdam
- Stream One
- Trammo
- Victrol
- James Fisher Fendercare (JFF)

James Fisher Fendercare (JFF), member of the OBT was involved in the pilot for the following functions:

- Providing technical expertise regarding cargo handling and safety protocols for the preparation of the pilot, including the development of the Joint Plan of Operations (JPO).
- Ensuring the availability and installation of the necessary additional equipment required for the safe execution of the pilot.
- Deploying Ship-to-Ship Superintendents to oversee the operation.
- Taking actions and preparing documents related to:
    - Functional safety requirements, such as redundancy, monitoring, purging, etc.
    - Compatibility assessment demonstrating the safety and compatibility of the transfer/bunkering systems of both the supplying vessel and receiving vessel.
- Providing expert representatives for the Operational Bunker Team and Technical Bunkering Group.

The Harbour Master division of the Port of Rotterdam was, in her capacity as a public authority, responsible for Safety and Governance during the ammonia bunkering pilot.

The OBT performed the following activities:

- A pilot specific HAZID/HAZOP. This HAZID/HAZOP also included the involved terminal, APMT, and was conducted in early March with expert guidance by DNV.
- This was followed by several pre-operation meetings.

These activities are further described below.

Risk Assessments

HAZID
A HAZID study was carried out in the form of an expert workshop with all participants of the OBT, including APMT, for the ammonia bunkering pilot in the Port of Rotterdam. The purpose of the risk assessment was to comprehensively review all preparatory activities and planned operations to ensure they would be executed in the safest possible way.

During the HAZID workshop a total of 119 risk scenarios were discussed of which 56 scenarios were risk rated. The remaining 63 scenarios either did not pose a safety threat, could not be identified as realistic (credible) scenarios or were a duplication of other scenarios.

Out of the risk rated scenarios 41 scenarios were assigned as low risk, 13 scenarios were assigned as medium (as low as reasonably practicable (ALARP)) risk, and 2 scenarios were assigned as high (intolerable) risk.

The 2 high risk scenarios and 1 scenario located in the upper medium region represent scenarios of greater significance. These scenarios are:

a. Risk of a hose rupture due to trapped liquid (same scenario for both options, bunker barge and ammonia carrier or 2 ammonia carriers.)
b. Risk of an ammonia release due to purging to open air.

For all scenario's recommended actions have been recorded addressing the procedures and mitigating the risks as far as reasonably practicable according to the 'as low as reasonably practicable' (ALARP) principle.

James Fisher Fendercare Risk Management Procedure
James Fisher Fendercare has established a *Risk Management Procedure* that provides a comprehensive approach for the complete risk assessment processes. For the ammonia bunkering pilot within the Port of Rotterdam the *Project Specific Risk Assessment* section was specifically relevant.

Hazard Identification Risk Assessment (HIRA)
After the above mentioned HAZID, James Fisher Fendercare conducted a Hazard Identification Risk Assessment (HIRA). This process involved bringing together the competence within JFF from their HSEQ department, Marine Assurance, and the appointed STS Superintendents to identify the hazards associated with the project, conduct a likelihood and consequence assessment, and to evaluate those risks on the basis of existing and additional controls. The guiding principle of this undertaking is to reduce the resultant risk of those hazards to *as low as reasonably practicable* (ALARP), thereafter determining if the residual risk rating of the operation falls within levels of acceptability. The controls identified within the risk assessment form the basis for implementation of a safe system of work.

Point of work risk assessment (POWRA)
Further to this HIRA, They also operated a *point of work risk assessment* (POWRA) system which recognises the importance of having an element of adaptability within the risk assessment process and provides an opportunity for the team carrying out the task to identify any additional hazards and risks which are local to the task either before

commencing the work or upon 'stopping the job'. These additional risk controls are added to the risk assessment prior to proceeding with the task.

The conclusion was:
"This assessment addresses and documents residual risks after control measures have been applied. Any issues that have not been considered as reasonably foreseeable or already deduced as being insignificant are not documented. The results of the Risk Assessment for STS Operations depend heavily on vessel suitability, competency of STS Superintendents, quality of STS equipment and good communication between all parties involved. Any corrective or additional Control Measures are to be assessed and applied locally by the STS Superintendents. Therefore, the risk is deemed as acceptable during the STS operations conducted by JFF during periods of good weather and good visibility. Information providing details for the onboard Emergency Response Plan must be provided by the master of the vessels to the JFF STS Superintendents before commencement of STS operations."

Pre-operation meetings

There were several processes and forms which support the conduct of meetings preceding various stages of the operation.

1. The completion of STS Checklist part1-3 (See Validation Sheet G Checklists) and the Joint Plan of Operations (JPO) (See Validation Sheet D JP(B)O) ensure vessels have a shared and agreed understanding of compatibility and the high-level operational details (including manoeuvring methodology, mooring arrangements, cargo transfer quantity and rate, means of communication, etc.) The JPO was created and STS checklist part 1 reviewed by the attending STS Superintendent/Person of Overall Advisory Control (POAC). The STS Superintendent/POAC was present to lead the completion of checklist part 2-3. These exchanges of information took place before the vessels were moored together.

2. Once the manoeuvring had been completed the STS Superintendent/POAC led a meeting between the vessels which focussed on operational safety for the cargo transfer and the exchange of essential information; this meeting was guided by the completion of STS Checklist part 4 and a further review of the JPO. Thereafter the Master and Chief Officer from each vessel directed the pre-operational meeting to ensure their individual needs for the exchange of information were met. This followed the format of their individual company International Safety Management (ISM) pre-cargo transfer operational documents. The STS Superintendent/POAC remains a party to this aspect of pre-operational information exchange to ensure a shared understanding of the operational plan was held between all parties and that the agreed transfer methodology was in compliance with equipment capabilities and local regulatory requirements.

Pilot recommendations

Recommendation 4.1a

When a non-adapted and non-licensed LPG carrier is used for an ammonia bunkering, supervision is needed for which external, experienced and competent service providers are mandatory to provide supervision on board. The supervisor should specifically be aware of in-port bunkering and specific local regulations and requirements for in-port operations such as control zones, and other operational aspects, or should manage the needed relevant knowledge and expertise.

Recommendation 4.1b

When a, for bunkering equipped and adapted LPG carrier is used on a regular base as an ammonia bunker vessel, crew needs to be experienced, competent and aware of specific local regulations and requirements for in-port operations such as control zones, Simultaneous Operations (SIMOPS), and other operational aspects. If knowledge on specific local regulations and requirements for in-port operations is missing, the bunkering should be supervised by an experienced and competent external supervisor.

Recommendation 4.1c

For a licensed and dedicated ammonia bunker vessels used for ammonia bunkering in a port, it is essential to ensure – which is assessed during the audit for the licensing process - procedures are in place to assure personnel involved possess the necessary competence, knowledge and awareness on in-port operations, local regulations, and specific aspects of in-port bunkering, such as control zones, Simultaneous Operations (SIMOPS), and other operational aspects.

Recommendation 4.1d

Stimulate training and competence on non-terminal related in-port operations for crew on board of ammonia fueled vessels.

Recommendation 4.1e

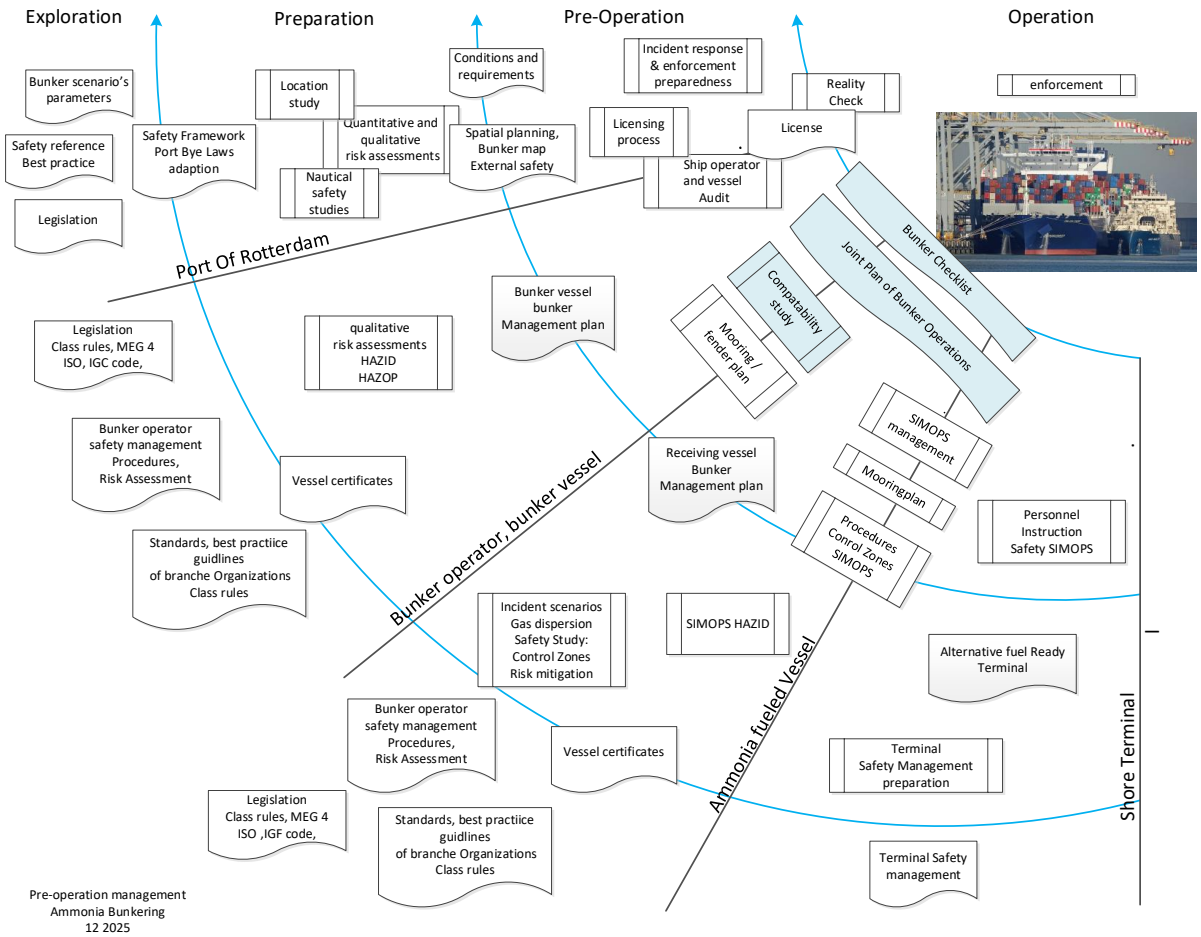
Develop training and competence requirements for crew on board of future dedicated ammonia bunker vessels with focus on local regulations and in-port bunker operation specific issues such as control zones, SIMOPS etc.

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment; PRL 7, 8 and 9

For every bunkering pre-operation management is necessary. All safety framework topics are required for pre-operation preparation. Information for level 7,8 and 9 can be found in the relevant Validation Sheets

Below figure shows a summary of the relevant topics in the exploration, preparation and pre-operation management.



Validation Sheet

VS A Bunker scenarios

This validation sheet is part of the MAGPIE ammonia pilot report. It is built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

Ammonia can in general be bunkered in various configurations depending on the state of the ammonia (refrigerated, semi-refrigerated, or pressurized) and the type of supply and receiving infrastructure. The key scenarios include:

Ship-to-Ship (STS) Bunkering [1]

- Description: Transfer of ammonia from a bunker vessel into the receiving ship.
- Variants:
  - With or without simultaneous cargo operations (SIMOPS).
  - In-port on dolphins or buoys, In-port alongside a terminal, at sea anchored, at sea while sailing

Shore-to-Ship Bunkering [2]

- Description: Transfer from a land-based terminal or storage tank to the ship.
- Variants:
  - Fixed pipelines or flexible hose systems.

Truck-to-Ship Bunkering [3]

- Description: Transfer of pressurized ammonia via ammonia tanker trucks to the ship, typically for smaller vessels or pilot projects.

Cassette Bunkering [4]

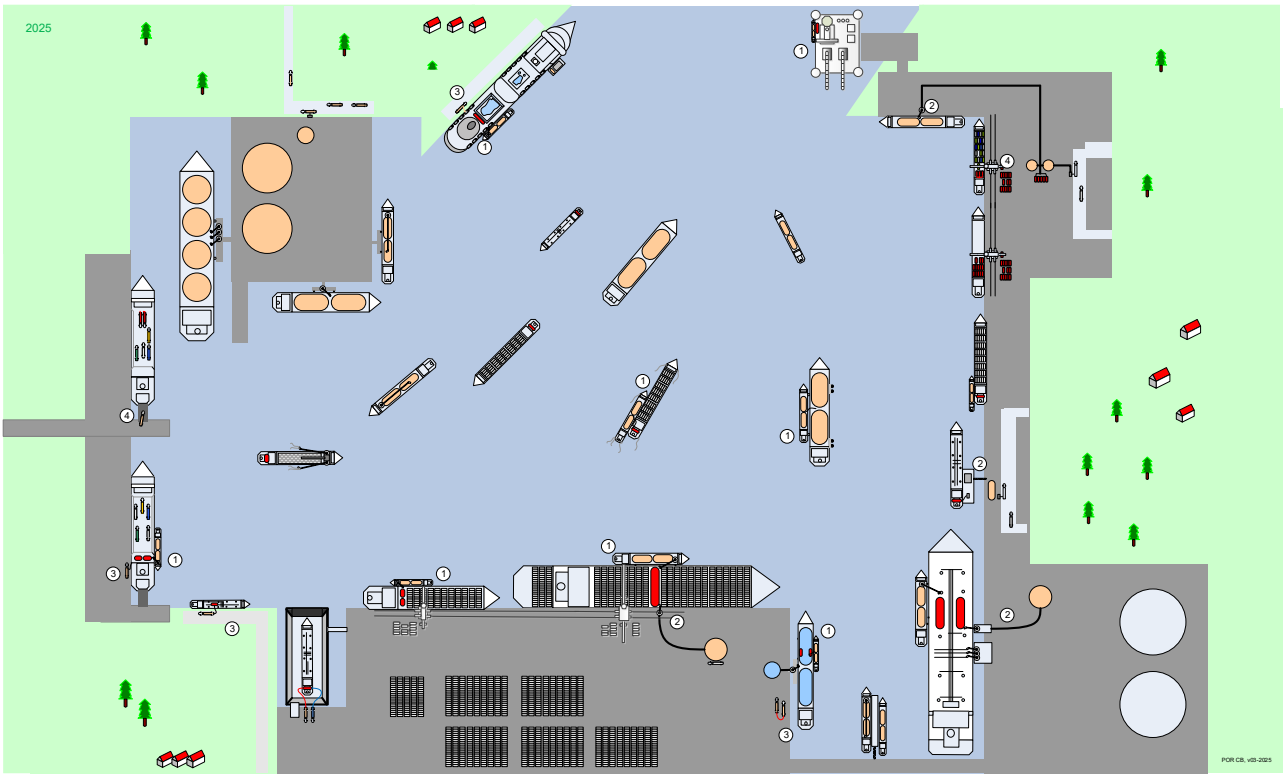
- Description: Use of pre-filled, swappable fuel tanks (cassettes) that are loaded onto the ship.
- Variants:
  - Containerized or in ISO tanks placed on board and are connected there
  - Tank trucks or trailers with a tank or container, that drive on board and are connected there

All bunker scenarios can involve fully refrigerated, semi-refrigerated, or pressurized ammonia.

However, in Rotterdam for ship-to-ship bunkering only cold ammonia (-33°C) is allowed. For all other bunker scenarios cold ammonia is preferred, although applications with semi-refrigerated and pressurized ammonia are still under discussion.

[1] See the bunker scenarios marked 1 in the drawing
[2] See the bunker scenarios marker 2 in the drawing
[3] See the bunker scenarios marked 3 in the drawing
[4] See the bunker scenarios marked 4 in the drawing

The "Beanport figure" shows all possible bunker scenarios in a port.



Pilot - PRL 6

During the pilot two LPG tankers were used of which one acted as receiving vessel and the other acted as ammonia bunker vessel. Although, from a technical point of view, the transfer was a Ship-to-Ship transfer of cargo, during the pilot an in-port Ship to Ship bunkering was simulated.

An alternative was also investigated which was the use of an existing LNG bunker barge. The preparation showed that this could be feasible but required preparation for checks and adaptations to the vessel as well as to manage the safe changeover from LNG to ammonia and vice versa avoiding contamination.

Pilot recommendations

Recommendation 2.1a:
Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia.

Recommendation2.1c:
Stimulate and support the use of two hoses (and a vapor return hose) for high transfer rates of ammonia instead a transfer with one high diameter hose. (e.g. 2x500 instead of 1x1000 m^3/h). Prohibit transfer rates in one hose above 1000 m^3/h.

Recommendation 2.4a
Be aware that for the use of an LNG bunker vessel as ammonia bunker vessel, time and investment is needed to do the preparation for 100% pilot suitability of the LNG bunker vessel. Aspects of importance are:
(1) bringing a dedicated bunker tank under ammonia atmosphere taking into account possible methane and nitrogen (used for purging) contamination with ammonia
(2) purging with nitrogen after the operation requires attention to ensure that there will not be contamination of ammonia in the bunker tank or tank of the bunker vessel with nitrogen
(3) Nitrogen in an ammonia bunker tank or ammonia cargo tank will affect the boil off gas management system due to the impact of nitrogen on compression equipment.

Recommendation 4.1a
When a non-adapted and non-licensed LPG carrier is used for an ammonia bunkering supervision is needed for which external, experienced, and competent service providers are mandatory to provide supervision on board. The supervisor should specifically be aware of in-port bunkering and specific local regulations and requirements for in-port operations such as control zones, Simultaneous Operations (SIMOPS), and other operational aspects, or should manage the needed relevant knowledge and expertise.

Recommendation 4.1b
When a, for bunkering equipped and adapted LPG carrier is used on a regular base as an ammonia bunker vessel, crew needs to be experienced, competent and aware of specific local regulations and requirements for in-port operations such as control zones, Simultaneous Operations (SIMOPS),and other operational aspects. If knowledge on specific local regulations and requirements for in-port operations is missing, the bunkering should be supervised by an experienced and competent external supervisor.

Recommendation 4.1c
For licensed and dedicated ammonia bunker vessels used for ammonia bunkering in a port, it is essential to ensure – which is being assessed during the audit for the licensing process - procedures are in place to assure personnel involved possess the necessary competence, knowledge and awareness on in-port operations, local regulations, and specific aspects of in-port bunkering, such as control zones, Simultaneous Operations (SIMOPS), and other operational aspects.

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment - PRL 7, 8 and 9

For the intermediate period, when LPG tankers will be used to bunker ammonia fueled vessels in the port of Rotterdam (Port Readiness Level 7), no other scenarios than the ship to ship bunkering scenario are expected, this has therefore been the focal point in the preparation.

To minimize the required safety distance between the bunker operation and vulnerable objects, the port will require bunkering with cold (-33° C) ammonia. For the same reason the use of two bunker hoses instead of one large diameter bunker hose is preferred for high transfer rates e.g. 2x 500 m^3/h instead of 1 x 1000 m^3/h.

First market initiatives to build and operate dedicated ammonia bunker vessels are initiated, these vessels are expected to come into operation in the period 2028-2030. Then port of Rotterdam will reach PRL level 8.

Bunkering with tank truck(s) or directly bunkering from an ammonia terminal are currently not foreseen. In case such scenarios occur, for example for pilot projects, this this will be handled as a project-based approach (PRL level 7).

Since the bunkering of cold ammonia for STS bunkering is mandatory to decrease the required safety distance to vulnerable objects (living quarters), cold ammonia is also preferred for bunkering by tank truck. However, for smaller applications pressurized bunkering is unavoidable. Additional safety mitigation measures will be required. This bunkering can be compared with the supply of pressurized ammonia for cool installations on board of (fishermen) vessels.

Cassette bunkering could be an option for inland vessel, but at this moment we see no initiatives to use this bunker scenario for (inland) shipping.

Validation Sheet

VS B Regulatory framework and licensing

This validation sheet is part of the MAGPIE ammonia pilot report. It's built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

The Rotterdam Port Regulations 2020 (Port Bye-Law) provide the legal basis for all port activities, including bunkering of alternative fuels such as ammonia.

The Harbour Master of the Port of Rotterdam is, in accordance with these regulations, mandated to exercise the powers granted by the Decision on Mandate, Power of Attorney, and Authorization Rotterdam 2021.

Given the toxic and hazardous nature of ammonia, stringent safety and environmental protocols must be applied.

The relevant sections of the Port Bye-Law are included at the end of this validation sheet.

Pilot - PRL 6

The pilot involved two LPG tankers performing a ship-to-ship refrigerated cold (-33°C) ammonia transfer in a non-dedicated area (not a petroleum harbour as stipulated in the Rotterdam Bye-Law). Although it was operationally treated as bunkering operation, with all associated safety procedures, in legal terms it constituted a gas transfer between two gas tankers.

Three exemptions were required and granted for this pilot operation, since:

- Transshipment of gas between two tankers is prohibited within the port limits.
  The pilot involved the transfer of gas. An exemption was needed for the operation.
- It is mandatory for a tanker with dangerous goods to berth in a harbour area designated as a petroleum harbour ('petroleum haven').
  The pilot was executed in an area that is not designated as a petroleum harbour.
  Both vessels needed an exemption to berth outside the petroleum harbour

Port Bye-laws Rotterdam 2020 (Relevant articles for licensing the pilot)

This text is translated from the Port Bye-laws which are in Dutch. In case of any misunderstanding the original text in Dutch must be referred to.

Article 6.4 Transshipment of gas
Transshipment of a gas as referred to in the IGC code or the ADN between two tankers is prohibited.

Article 5.4 Tankers carrying dangerous substances
1. Tankers with cargo or slop tanks containing dangerous substances or residues thereof may only berth at a petroleumhaven.

Article 6.2 Checklist for the transshipment of dangerous or harmful liquids in bulk
1. Direct transshipment of dangerous or harmful liquids between tankers or transshipment between a sea-going tanker and a location at which the activity is permitted may only take place if the checklist as referred to in ISGOTT, StSTGP or ISGINTT has been completed and signed by the parties involved for that activity in line with the provisions of the aforementioned checklist.
2. The transshipment must take place in line with the checklist.

Deployment - PRL 7

When an LPG tanker acts as an ammonia bunker vessel (Port Readiness Level 7), a short-term permit under Port Bye-Laws Article 8.1 is required for each bunkering operation.
Process:

- Submit standard application to Harbour Coordination Center
- Back-office specialists review and request additional documentation:
  - Vessel and crew details
  - Compatibility assessment results
  - Joint Plan of Bunker Operations (JPBO)

The decision considers planning, location, terminal readiness, external and nautical safety, SIMOPS and feasibility.
If approved, a short-term permit is issued detailing situation-specific risk mitigation measures based on the safety assessment and JPBO.

Deployment - PRL 8 and 9

Dedicated ammonia bunker vessels (Port Readiness Level 8) have to apply for a long-term license to bunker at locations approved by the Rotterdam Port Authority.

See VS F002: External safety

Applications for non-approved locations must follow the PRL7 process. A short term permit may be issued based on a location specific risk analysis and the implementation of appropriate risk mitigation measures.

License Conditions:

- Operator must successfully complete a comprehensive audit (IAPH Audit Tool)
- Audit checks such as:
  - Compliance of safety management system and procedures with standards and best practices.
  - HSEQ office review, vessel inspection, and Reality Checks during initial operations.

  - Compliance with local port Bye Laws, and procedures for SIMOPS, JPBO, signaling, and the use of checklists.
- Compliance with international guidelines:
  - SGMF – Ammonia Safety and Operational Guidelines – Bunkering.
  - IAPH - Audit Tool for auditing Bunker Facility Operators
  - IAPH - IAPH Clean Marine Fuels Working Group Bunker Checklists

Upon a positive audit, a long-term license is granted with additional safeguards.

Port enforcement officers may conduct reality checks and inspections during bunker operations at any time.

Relevant regulations Port Bye Laws Rotterdam 2020

Port Bye-laws Rotterdam 2020 (Relevant articles for licensing of bunkering)

This text is translated from the Port Bye-laws which are in Dutch. In case of any misunderstanding the original text in Dutch must be referred to.

(See rotterdam-port-by-laws-2020-july-2023.pdf)

Article 1.1 Terms:
Bunkering: the supply of solid, liquid or gaseous fuels or any other source of energy used for propulsion of ships or for the general or specific energy supply on board ships.

Article 8.1 Bunkering

a. The municipal executive may designate fuels or energy sources that may be bunkered or debunkered by anyone who has a permit from the municipal executive.
b. The municipal executive can designate areas or berths where:
1. bunkering or debunkering is prohibited;
2. bunkering or debunkering is permitted, or;
3. bunkering or debunkering according to that stated in the first subclause is only permitted for certain fuels or energy sources.
c. The municipal executive can designate fuels that may not be bunkered.
d. A permit is not required if the bunkering or debunkering takes place at a company at which these activities are permitted.

Article 8.2 Minimum requirements of a bunker permit

a. The municipal executive can set minimum requirements on the permit and the permit holder of the bunkering permit.
b. These minimum requirements can relate to:

- the permit holder's professional qualifications, the permit holder's staff or the natural persons who effectively and continuously manage the permit holder's activities;
- the permit holder's financial standing;
- the equipment needed for bunkering under normal and safe conditions and the ability to maintain this equipment at the required level;
- the availability of the permit holder to bunker or debunker at all berths and without interruption, day and night, throughout the year;
- compliance with requirements relating to maritime safety or the safety and security of the port or access to the port, its installations, equipment and employees and other persons;
- compliance with local, national, European and international environmental requirements, and;
- the good repute of the permit holder, as determined in accordance with applicable national law on good repute, taking into consideration any compelling grounds to doubt the reliability of the provider of port services.

Port Bye-laws Rotterdam 2020 (Relevant articles for licensing for bunkering)

This text is translated from the Port Bye-laws which are in Dutch. In case of any misunderstanding the original text in Dutch must be referred to.

Article 8.3 Fulfilling minimum requirements for a bunker permit

- The permit application should include the information set out in an application form as adopted by the harbour master.
- The municipal executive can determine that, for certain fuels or energy sources, additional details must be provided during the permit application. This additional information relates to the regulations and restrictions referred to in the third subclause and could relate to an audit that the municipal executive may conduct for bunkering or debunkering activities carried out by the company.
- Conditions and restrictions may be attached to the permit, including:
  - the location where bunkering or debunkering may take place and the safety distances that must be taken into consideration during bunkering or debunkering;
  - operational safety and the procedures governing the performance of bunkering or debunkering, as well as whether or not to permit other activities to take place simultaneously with bunkering or debunkering;
  - nautical safety;
  - external safety;
  - making operational reports related to bunkering or debunkering, and;
  - the subjects referred to in article 8.2(2).

Designation decree for fuels and energy sources that may be bunkered with a permit only, 2021

Article 1 Bunkering or debunkering with a ship

The following fuels or energy sources may not be bunkered or debunkered from a ship to another ship without a permit:

- residual fuels and distillates (fuel oil and diesel);
- biodiesel;
- LNG or liquefied bio natural gas (BLG);
- methanol or biomethanol;
- ethanol or bioethanol;
- ammonia;
- hydrogen or hydrogen carriers
- electricity;
- packaged fuels or energy sources;
- energy-supply or energy-production units;
- fissile materials.

Article 8.7 Checklist for bunkering and debunkering and transferring ancillary substances on board

- The municipal executive may establish checklists for bunkering or debunkering or for transferring ancillary substances from or on board;
- The municipal executive can designate fuels, energy sources and ancillary substances as well as categories of vessels in which a checklist applies to the bunkering or debunkering of these.
- The parties involved must complete a bunkering or debunkering checklist and must comply with this checklist and keep it on board the vessels concerned for at least 24 hours after the end of bunkering or debunkering.

Validation Sheet

VS C Compatibility Assessment Ammonia STS Bunkering

This validation sheet is part of the MAGPIE ammonia pilot report. It is built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

When planning a Ship-to-Ship ammonia bunkering, the parties must confirm ship compatibility to ensure safe, efficient, and environmentally responsible transfer. Ammonia is toxic and corrosive, therefore requiring strict handling measures.

The assessment should verify technical compatibility between bunker vessel and receiving vessel for the following reasons:

Ensure technical compatibility between vessels' manifolds, hoses, communication systems, and ESD.
Identify interface mismatches early to avoid unsafe or inefficient operations.
Verify safety systems, especially linked ESD arrangements and emergency protocols
Plan safe operations and reduce risks (e.g. prevent accidents, leaks, or equipment failures)
Ensure regulatory compliance with international regulations, class rules, and port requirements.
Align operational procedures and competence between both crews.
Prevent operational delays caused by incompatible systems.

The Joint Plan of Bunker Operations (JPBO) must reflect the compatibility assessment outcome.

References

CDI/ICS/OCIMF/SIGTTO: STS Transfer Guide
ICS/OCIMF/IAPH: International Safety guide for oil tankers and terminals
SGMF Ammonia Bunker Guide
Port Bye Laws Rotterdam
IAPH STS Bunker Checklist

Additional to the regular commercial, nautical and technical issues for Ship-to-Ship transfer, during the compatibility assessment, ammonia bunker specific topics should be addressed:

Local and Site requirements:
- Local regulations and approvals
- Control of site's electrical site equipment in the Hazardous zone
- Gas dispersion study as base for control zones
- Control zones and safety measures
- Controlled acces to safety and hazardous zone
- Approved safety distance to public (external safety)

Mooring:
- Mooring analyses
- Mooring points
- Mooring loads
- Mooring lines
- Mooring gear load limits (bollards, chocks, rollers etc.)
- Fendering
- Hull form flat side
- Overall dimensions
- Bridge wings
- Freeboard

Equipment:
- Approved transfer equipment
- (Remote) monitoring system
- Electrical insulation
- International shore connection
- Crane and crane reach
- Loading arm and arm reach
- Bunker boom
- Hoses
- Hose support equipment
- Deluge System
- Drip trays, gutters
- Operational emission processing equipment
- Vapour recovery equipment
- Contaminated water containment system and treatment plant

Manifold:
- Distancing
- Spacing, orientation
- Height and strength
- Layout
- Instrumentation
- Connections size and design
- Cryogenic protection
- Manifold covers
- Manifold mist/water spray
- Spill containment and knock out tank for spilled liquid fuel

Connection:
- Lifting arrangements
- Bunker hose configuration
- Distancing (between manifold and bunkerstation - height and length)
- ESD / (P)ERC, BSL, ERS, TRV

Bunkering and safety measures:
- Freeboard differences during bunkering
- Draft and tidal changes
- Weather and Wave conditions
- Vessel separation detection with ESD function
- Bunkering operational procedures including cooling down, sampling and tests
- Transfer data
- Maximum allowable parameters
- Means for purging without emision
- BOG / vapour management
- Hazardous area classification and control
- Exposure distances conform industrial standards
- SIMOPS plan and Risk Assessment

People:
- Personnel Instruction
- Incident response instruction and training
- Familiarity of personnel with safety areas and safety measures during bunkering
- Emergency stop signal and shutdown procedures
- Organisation Roles and Responsibilities
- PIC appointment
- Responsibilities PIC and manifold crew in charge
- Supervision

Incident response:
- Fire control plan
- Liquid gas spill control plan
- Toxic gas dispersion control plan
- After release mitigation system
- Emergency Response procedures
- Contingency planning

Communication:
- Joint Plan of Bunker Operations (JPBO)
- Means of communication
- Communication procedures and contact
- Details involved parties
- Language
- Communication PICs
- Data communication between safety- and ESD systems

The list of topics is an unlimited open guidance and can be expanded with other topics. (Source: IAPH/CMF bunker checklist)

Pilot - PRL 6

Two LPG tankers carrying ammonia were used for the ammonia bunker pilot, the operation was prepared as a cargo transfer. The STS service provider applied internal documentation and pre-fixture checklists based on STS Transfer Guide and the Q88 document. The Questionnaire 88 is the industry-standard chartering questionnaire for tankers, developed by INTERTANKO.Q88, to

- assess the suitability of a vessel
- review safety and technical information
- speed up the vetting (screening) process
- evaluate risks and regulatory compliance

The pilot compatibility assessment was covering:

- Arrival/departure: displacement, LOA, freeboard, ballast;
- Manifold & reducers;
- Moorings, winches, bow thrusters;
- Cranes, hoses;
- Fenders;
- Weather, rolling angles, approach speed;
- Transfer parameters & safety equipment;
- ESD and VSD-PERC systems.
- The pilot included an STS Risk Assessment (HAZID), with additional risk controls integrated into the JPO. Pilot specific equipment (including hoses) was supplied by barge to both vessels.

Pilot recommendations

Recommendation 4.2a
For in-port operations assure that appropriate, sufficient, calibrated, tested and operational monitoring/detection equipment/systems are available on board of both involved vessels.

Recommendation 4.3a
Implement in the Safety Management System that all equipment to be used for bunkering needs to be certified for ammonia and checked on certification before transfer to the vessel.

Recommendation 4.3b
In the compatibility assessment, done before the operation, address the hoses, including the suitability of the hose, the hose certificates and the test log.

Recommendation 4.3c
Do a final check on the suitability of the equipment before transfer on the vessel.

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment - PRL 7, 8 and 9

For PRL 7, 8 and 9 the compatibility assessment should be applied as shown in the general introduction of this validation sheet.

The assessment is both a confirmation of suitability and an information exchange. Even non-applicable items provide value for all parties.

Validation Sheet

VS D Joint Plan of (Bunker) Operations – JPBO

This validation sheet is part of the MAGPIE ammonia pilot report. It's built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

The JPBO is the operational agreement for STS ammonia bunkering between two vessels at a planned location. It defines procedures, safety measures, and environmental controls. All parties (ship crews, terminal operators, port authorities) must comply with the conditions in the JPBO. Its content is established within the standard IAPH bunker checklists, which record the required topics and agreements between the parties involved.

The JPBO is based on:

Bunker management plans of both vessels
Compatibility assessment between the supplying and receiving vessel
Situation -specific HAZID results
Local conditions and regulations
The JPBO ensures alignment on bunker procedures, timing, responsibilities, safety zones, emergency response and port specific requirements. Due to ammonia's toxic, corrosive, and flammable properties, strict containment and safety measures apply.

References

CDI/ICS/OCIMF/SIGTTO STS Transfer Guide & ISGOTT: Nautical and operational guidance.
SGMF Ammonia Bunker Guide
Port Bye laws: Port-specific requirements.
IAPH STS Bunker Checklist: General, transfer system, roles, vessel details, bunker preparation, operation, emergencies.

Additional to the regular nautical, technical Ship to Ship transfer topics, ammonia bunker specific topics should be addressed in the JPBO:

General - Unique Bunker Identification Number (BIN) - Purpose and scope of the JPBO - Report of the Compatibility check **Transfer system** - ERS - ESD link - ESD test - Spill /gas detection and control systems **Roles and Responsibilities** - Organization - Responsibilities PIC vessels and manifold crew in charge - Mandatory permissions **Bunker operation** - Approach - Mooring - Checklist to be used, latest version - Handling and connection of bunker hose and vapor return hose - (Remote) monitoring system - Hose Saddle, Deluge System, Manifold Connection, Drip trays, gutters. - Connection, pressure test, purging, cooling down, gassing up - Environmental Operating Limits - PPE, personal safety - Eyewash and decontamination showers - Manifold water screen - Draining, purging disconnecting, inerting - Post transfer procedures - Unmooring	**Vessels details** - Description of the involved vessels - Specification of the ships - Access to the vessel and access control of safety zones (including supervision) **Bunker preparation** - Mooring analyses report, mooringplan - Description of location, bunkering zones - Description of safety zones - Fendering / mooring - Safety meeting - Bunker transfer: equipment and procedures - Energy carrier supply specification - Volumes (Quantities and characteristics) - Communication (e.g. language), contact details - SIMOPS - Control zones, safeguards **Emergencies** - Emergency preparedness and response - Contingency planning - Sequence of actions in case of a spill - Hull protection, water screens - Spill /gas release control systems - Emergency shutdown system - Emergency release system

The list of topics is an unlimited open guidance and can be expanded with other topics.
(Source: IAPH/CMF bunker checklist)

Pilot - PRL 6

Two LPG tankers carrying ammonia were used for the pilot. A Joint Plan of Operations (JPO), prepared in accordance with the STS transfer guide, was developed based on the compatibility assessment and vessel documentation. the plan covered both nautical and transfer aspects, listed below:

- Nautical topics

Vessel particulars
Approach parameters
Agreed vessel parameters
Local berth details
Mooring & fendering studies and plans
Communications
Weather limits

- Transfer Topics

ISPS security level (1)
Emergency response & contingency plans
Escape routes
External emergency response
Odor nuisance control
Communication and Contact info
Personnel transfer
Supplied equipment (via barge)
Vessel Separation Detector
STS transfer plan
Rigging
Pressure leak test
ESD pendant test (closing time 25–28 sec)
Cooldown procedure cargo line
Transfer parameters
Vapor & tank pressure management
Notices for transfer, completion steps
Draining, purging, hose disconnection
PPE requirements
Schematic manifold drawing
Hose envelope
Unmooring plan

Pilot recommendations

Recommendation 3.6
Ensure that all relevant personnel, service providers, and other third parties are informed about the applicable restrictions and procedures.

Recommendation 4.6a
Incorporate into the purging procedure the recommendation of hot gassing with ammonia, including the appropriate requirements to be agreed upon in the JPBO.

4.6b Recommendation
Standardize for in-port operations the acceptable maximum remaining concentration after purging before disconnection in the ammonia bunker transfer line and vapour return line (if used) on max 25 PPM measured at the furthest end from the nitrogen injection point, to avoid hindrance or smell due to the low odor.

Recommendation 4.10a

- *The operation shall be performed in compliance with the JPBO and applicable instructions, and these requirements should be known by all relevant crew members.*
- *All relevant people should participate in the pre-operation meeting.*
- *During the pre-operation meeting address:*
  - *all transfer and purging parameters agreed upon in the preparation phase.*
  - *location specific items and topics relevant to in-port ammonia bunkering.*
- *The Person in Charge (PIC) of both vessels is responsible for ensuring that all the relevant crew members are aware of these parameters.*

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment: PRL 7, 8 & 9

For PRL 7, 8 and 9 the Joint Plan of Bunker Operation (JPBO) should be applied as shown in the general introduction of this validation sheet.

Start with nautical topics per STS Transfer Guide & ISGOTT.
Add technical transfer details (manifold, hoses, parameters).
Incorporate topics of the IAPH Ship-to-Ship Bunker Checklist Part A2 for local and ammonia-specific requirements: spill/gas detection, water screen systems, contaminated water containment, control zones risk mitigation, SIMOPS, ammonia release mitigation, spill control, terminal preparedness.
JPBO is not just a work order; it is an information exchange. Even 'not applicable' items provide value.

Validation Sheet

VS E Pre-Operation Meeting

This validation sheet is part of the MAGPIE ammonia pilot report. It's built up as follows: first a general introduction of the topic and then how this topic relates to each Port Readiness Level (PRL). It includes the level 6 pilot insights and recommendations, and the level 7, 8, 9 requirements related to the topic.

General

Ammonia is a highly toxic and hazardous substance. Its handling demands strict safety protocols, clear communication, and thorough coordination among all parties. A pre-operation meeting ensures alignment on procedures, risks, and emergency measures, reducing incident likelihood.

A key element is the review of the JPBO (Joint Planning and Bunkering Operations) document, which defines agreed procedures, safety measures, and communication protocols between the bunker supplier and the receiving vessel or terminal. Additionally, the relevant section of the IAPH Ammonia Bunker Checklist must be completed during the meeting. https://www.iaphworldports.org/products/

Topics to Address:

- JPBO Review: Roles and responsibilities, bunkering steps, safety and emergency protocols.
- Bunker preparation and bunker operation including specifics on
    - toxicity & safety: vapor handling, gas detection, ventilation, PPE requirements.
    - operational Planning: Start/end times, transfer rates, total volume, connections, equipment compatibility.
- Port-Specific Requirements: Control zones, risk mitigation, SIMOPS, terminal readiness.
- Environmental & Health: Spill prevention, first aid, decontamination, weather monitoring.
- Emergency Response: Alarm signals, evacuation, escape routes, firefighting, coordination with local services.
- Communication Protocols: Channels, contact persons, reporting intervals, incident reporting.
- Documentation & Permits: Verification of permits, safety checklists, compliance with regulations

Any deviation requires a Task Risk Assessment and must be documented in the JPBO and IAPH checklist. The meeting ensures alignment with port safety zones, emergency plans, and regulations.

See VS D: Joint Plan of Bunker Operation (JPBO)

In Rotterdam, physical meetings with all Persons in Charge are preferred. If boarding the vessel poses excessive risk, alternatives such as video calls may be used once routines are established.

References

CDI/ICS/OCIMF/SIGTTO STS Transfer Guide & ISGOTT: Nautical and operational guidance.
SGMF Ammonia Bunker Guide
Port Bye laws: Port-specific requirements.
IAPH STS Bunker Checklist: General, transfer system, roles, vessel details, bunker preparation, operation, emergencies.

Pilot - PRL 6

The pilot involved two LPG tankers transferring ammonia. Technically, this was a cargo transfer between vessels, and during the pre-operation meeting the JPO (as for cargo transfer) was used to define the agreements for safe operations with an additional check on relevant JPBO (bunker specific) items. During the pilot, the meeting resembled a compatibility and JPO review, including the bunker specific topics, rather than an information exchange.

Communication during the pre-operation meeting was via VHF radio. While structured with message repetition, radio interference caused misunderstandings, highlighting its limitations and leads to a preference for an in-person pre-operation meeting.

Governance measures, control zones, external safety, incident response, and communication were pre-arranged and included in, amongst others, the JPO and incident response plan.

- Since, during the pilot, other parties were involved in arranging parts of the bunker specific safety topics, e.g. the Patrol vessel of the POR assured the nautical safety zone etc., the pre-operation meeting could focus on the safety of the transfer and (dis)connection.

As this was the first time ammonia bunkering was performed in port alongside a terminal, extra attention was paid during the pre-operation meeting to:

- Responsibilities (POR supervision, STS Superintendent, Vessels officers.)
- Hot gassing temperature
- Quantity measurement
- Maximum pumping rate
- Full awareness and agreement on JPBO content.

Pilot recommendations

Recommendation 3.6
Ensure that all relevant personnel, service providers, and other third parties are informed about the applicable restrictions and procedures.

Recommendation 4.1a
When a non-adapted and non-licensed LPG carrier is used for an ammonia bunkering supervision is needed for which external, experienced and competent service providers are mandatory to provide supervision on board. The supervisor should specifically be aware of in-port bunkering and specific local regulations and requirements for in-port operations such as control zones, and other operational aspects, or should manage the needed relevant knowledge and expertise.

Recommendation 4.1b
When a, for bunkering equipped and adapted LPG carrier is used on a regular base as an ammonia bunker vessel, crew needs to be experienced, competent and aware of specific local regulations and requirements for in-port operations such as control zones, Simultaneous Operations (SIMOPS) and other operational aspects. If knowledge on specific local regulations and requirements for in-port operations is missing, the bunkering should be supervised by an experienced and competent external supervisor.

Recommendation 4.1c
For licensed and dedicated ammonia bunker vessels used for ammonia bunkering in a port, it is essential to ensure – which is being assessed during the audit for the licensing process - procedures are in place to assure personnel involved possess the necessary competence, knowledge and awareness on in-port operations, local regulations, and specific aspects of in-port bunkering, such as control zones, Simultaneous Operations (SIMOPS) and other operational aspects.

Recommendation 4.3c
Have a final check on the suitability of the equipment before transfer on the vessel.

Recommendation 4.10a
- *the operation shall be performed in compliance with the JPBO, and applicable instructions and these requirements should be known by all relevant crew members.*
- *all relevant people should participate in the pre-operation meeting.*
- *address during the pre-operation meeting:*
- *all transfer and purging parameters agreed upon in the preparation phase.*
- *location specific items and topics relevant for in-port ammonia bunkering.*
- *the PIC of both vessels is responsible for ensuring that all relevant crew members are aware of these parameters.*

See the Validation Sheet 00 "Pilot lessons learned and recommendations".

Deployment - PRL 7

For the intermediate phase, where LPG tankers serve as ammonia bunker vessels in Rotterdam, pre-operation meetings must address all items listed in the general section of this validation sheet. The pre-operation meeting will be led by the External Superintendent (if applicable) The JPBO and transfer parameters must be reviewed, and the IAPH checklist version A must be completed with involvement of the terminal.

Deployment - PRL 8 and 9

For future operations with dedicated ammonia bunker vessels, pre-operation meetings must address all items listed in the general section of this validation sheet. The pre-operation meeting will be led by the vessel officer appointed as Person in Charge (PIC) The JPBO and transfer parameters must be reviewed, and the IAPH checklist version B must be completed. The terminal should be informed using the "Terminal Information Sheet" of the IAPH B bunker checklist.

In cases of regular bunkering between the same vessels at the same location physical meetings can be replaced by alternative communication methods such as video calls and digital IAPH checklists completed via Wi-Fi.

Validation Sheet

VS F001 Pilot Governance

General

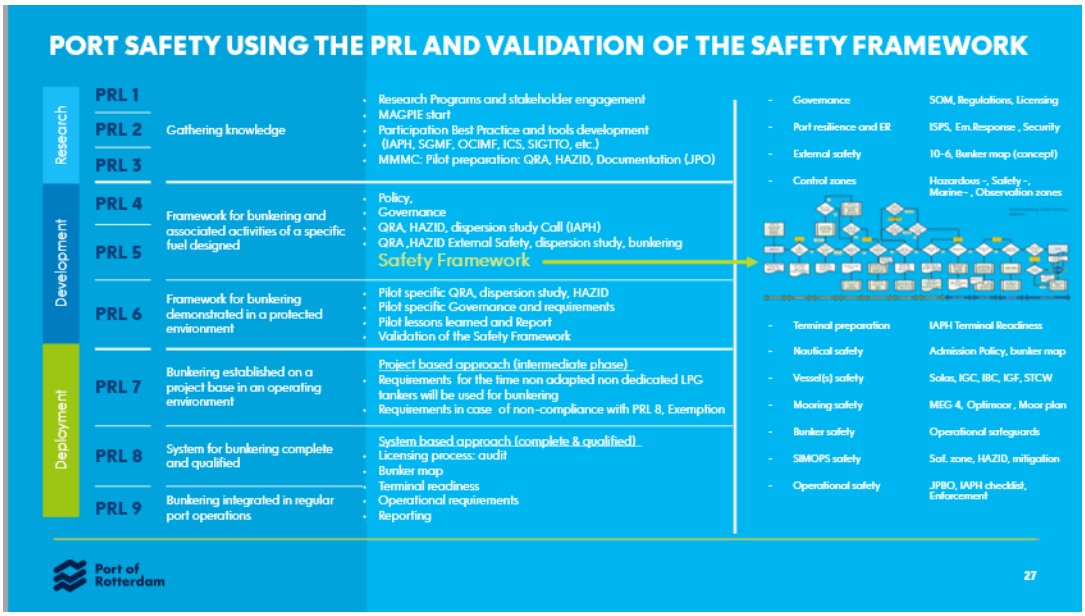
Setting up an ammonia bunkering pilot requires a detailed governance structure to ensure safety, operational efficiency, and regulatory compliance.

See the VS 01 for the explanation of the Port Readiness Level methodology and Safety Framework.

In this document we show what governance aspects were addressed for the pilot as well as for future ammonia bunkering:

1. **Port Readiness nine steps approach:** For the preparation of the ammonia bunker pilot, we used IAPH's "Port Readiness Level" methodology. This structured nine level approach, was already started in 2020 with the research phase (first 3 levels). The Port of Rotterdam Authority (PoR) carried out feasibility studies and programs to get aware of the pros and cons of ammonia as a fuel (PRL 1,2 and 3). In 2023 PoR made progress to develop a policy for ammonia fueled vessels including a roadmap (PRL 4) to create a spatial planning and safety framework for bunkering. Risk assessments, HAZIDs and HAZOPs were developed and PoR participated in working groups and programs to develop best industry practices. With all this input the safety framework for ammonia bunkering was then developed (PRL 4 and 5) which allowed for the pilot preparations. Finally, in PRL6 the safety framework was validated, providing a basis to facilitate future ammonia bunkering in Rotterdam (level 7, 8 and 9)

   Although in this document the focus is on ammonia bunkering in Rotterdam, the used methodology and resultslocations can also be used for other clean marine fuels and other locations.



2. **Regulatory Framework**: In 2020 the Port Bye Laws of the Port of Rotterdam were amended to ensure its applicability to the bunkering of ammonia fueled vessels. This includes a licensing system based on a safety management audit of future ammonia bunker operators. Of course, there are also national and international regulations applicable for ammonia fueled vessels (IMO IGF, ES-TRIN) and ammonia bunker vessels and ammonia tankers (IMO IGC, ADN). During the five-year preparation leading up to PRL 6, PoR participated in workgroups to develop safety instruments for ports such as operational checklists (IAPH/CMF) and best practice guidelines (SGMF, OCIMG/ICS) to be used as "safety reference" for the Port Bye Laws Rotterdam, and PoR participated in the MAGPIE program to initiate an ammonia bunker demo. The Regulatory Framework is a part of the governance a port needs to have established.

   See: Validation sheet B: Regulatory Framework and Licensing and Validation sheet F006: Vessel safety

3. **Safety framework**: Based on the Safety Framework developed for LNG bunkering, PoR developed the Rotterdam safety framework for ammonia in 2023, which also addresses the special safety aspects of ammonia. In it the safety conditions required for future ammonia bunkering are described. In the safety framework the following issues are addressed:
   - Governance
   - External safety
   - Control Zones
   - Terminal preparation
   - Nautical safety
   - Vessel safety

- Mooring safety
- Bunker safety
- SIMOPS
- Operational safety and enforcement
- Port resilience and Emergency Response preparedness

See: Validation sheets F001 to F011

4. **Risk Assessment**: PoR conducted comprehensive risk assessments to identify potential hazards and developed mitigation protocols. The following was done:

   - A Quantitative Risk Assessment (QRA) based on multi ammonia bunker scenarios as input to develop an "Ammonia Bunker map" to assure sufficient safety distance to vulnerable areas or populated aeras (performed by DNV).
   - A gas dispersion study for the pilot bunker scenario (performed by DNV) to set control zones for future bunker scenarios.
   - A risk assessment and gas dispersion study for a call of an ammonia fueled vessel (performed by DNV)

Pilot - PRL 6

See for below topics the validation sheets F001 to F011

1. **Risk Assessment**: PoR conducted specific pilot risk assessments to identify potential hazards and developed mitigation protocols. The following was done:

   - A gas dispersion study for the pilot bunker scenario (performed by DNV) to set control zones for the ammonia bunker pilot.
   - A HAZID/HAZOP specific for the ammonia bunkering pilot (performed by DNV).

2. **Site Selection**: Pilot was conducted alongside a new quay at the Maasvlakte 2 APM terminal. APMT was agreed upon as a suitable ammonia bunkering pilot location based on:

   - the distance to vulnerable areas; the nearest populated area was at nine-kilometer distance;
   - nautical criteria, the quayside was ready for use, with all necessary mooring equipment available, accessible with enough draft;
   - low nautical traffic, it was located at the end of the port basin with no passing vessels. During the pilot the vessel traffic was suspended, safeguarded with a standby PoR firefighting and patrol vessel;
   - willingness of the terminal to facilitate and prepare the terminal as "Ammonia Ready Terminal";
   - low activities in the direct vicinity, the location was alongside a part of the terminal that was still under construction. To minimize people in the direct vicinity during the transfer, the window for the transfer was set between 18:00-07:00hrs.

The allowed locations for future ammonia bunkering will be based on the final "Ammonia Bunker Map" and the license requirements of the ammonia bunker operator.

3. **Operational Guidelines**: For the preparation of the ammonia bunker pilot a compatibility assessment was performed by the pilot superintendent (JF Fendercare), a detailed operational plan (JP(B)O) was developed for the ammonia bunkering, including procedures for mooring, safety equipment, the transfer of ammonia, and purging of the lines.

4. **Training and Competence**: The competence and training of the crew of both vessels was compliant with the STCW requirement. A service provider as superintendent of the STS transfer provided additional experienced personnel and competences. Rotterdam Emergency responders, due to their preparation for possible incidents at the Ammonia terminal in Rotterdam, were already prepared for incidents with ammonia.

5. **Incident Response Preparedness**: The first response in case of an incident during transfer of ammonia will be performed by the crew of the vessel. Based on the vessel's emergency response and contingency plans, the crew is equipped and trained for first response.

   The second party in the response is the terminal. Depending on the type of terminal there are different action perspectives. A gas- or liquid bulk terminal will have firefighting monitors and other equipment stand by to use, important aspects for an action perspective for container terminals is awareness, an alarm system, also for the warning of terminals in the vicinity, and an evacuation protocol to send people to safe areas.

   The third party involved will be Port's Emergency and Incident Response organization (ERO). This is as joint effort between safety organizations in the Port of Rotterdam. This organization in the port of Rotterdam is trained and equipped for incidents with ammonia. Incident scenarios are defined, and incident response scenarios are developed and trained. However, incidents response scenarios for STS ammonia transfer or ammonia bunkering are not yet developed. For the pilot a dedicated Emergency Response plan was developed. For future bunkering the bunker incident scenarios will be incorporated in the existing system for competence building, training and equipment. The pilot was also an opportunity to test the communication lines in case of an incident.

6. **Enforcement and supervision:** During the pilot, two Port of Rotterdam Harbour Master division inspectors were on board to ensure compliance with the safety requirements and regulations.

7. **Stakeholder Engagement**: Besides the parties involved in the pilot, all relevant stakeholders were informed or involved, to foster trust and collaboration. This included other authorities including the city council, Environmental Agency, Safety Region, companies in the relevant area of the pilot and public.

   See: Validation sheet I: Strategic Stakeholder Management and communication

8. **Monitoring, validation and evaluation**: For the ammonia bunker pilot this report is available. For the future bunker activities PoR will implement systems for

continuous monitoring and evaluation of operations to drive improvements and to develop or refine best practices.

Pilot management

To manage the ammonia bunker pilot project, eight teams were established, all with separate tasks and responsibilities.

- *Pilot management team:*
  Development of the operational agreement to address commercial issues such as cooperation, responsibility, liability, costs and management of all the working groups
- *Operational Bunker Team:*
  Focus on a safe operation: compatibility check, JPBO, checklists, safeguards, connections, transfer, purging disconnection.
- *Enforcement team:*
  A team of POR inspectors and safety specialists from the Harbour master division for supervision on safety and compliance conform regulation, agreed procedures and JPBO.
- *Governance team*
  A team of Rotterdam authorities (EPA, ERO and Incident response officers) looking into to pilot specific incident response and communication. This team also developed the incident response plan for the Rotterdam incident response organization.
- *Strategic Stakeholder management and communication team:*
  This team developed a communication plan to reach out to all stakeholders in the pilot area and communication to public in the area and small villages in the neighborhood. An "ammonia pilot factsheet" was developed and distributed to all relevant stakeholders.
- *Vicinity team*
  The vicinity team was established to reach out to companies in the inner control zones. These companies should be prepared for a possible spill of emission of ammonia that will affect their companies.
- *City team:*
  The city team arranged the communication with the city administration and the cabinet of the Mayor and Aldermen. of Rotterdam.
- *Validation team*
  The validation teams took care, after the pilot, of the evaluation, the validation of the Rotterdam safety framework and MAGPIE reporting

The communication to all involved parties started already more than a year before the pilot, however, the tactical preparation done by above workgroups could only commence once the vessels were finally nominated and the location was approved. This happened three months before the actual pilot.

All teams performed well, under high time pressure due to the unavoidable changes that were made during the last two months of preparations.

The result of the work of the teams can be found in the validation sheets.

Deployment - PRL 7

The governance for future ammonia bunkering will be covered by the validated and approved safety framework and operational procedures of PoR.
The regulatory framework is in place, the Port Bye Laws regulations are adapted for Ammonia bunkering and procedures for (short term) licensing are in place.
The governance for ammonia bunkering will have a project-based approach with short term licensed for every requested bunkering.

Deployment - PRL 8 and 9

The governance for future ammonia bunkering with dedicated ammonia bunker vessels will be covered by the validated and approved safety framework and operational procedures of PoR. The regulatory framework is in place, the Port Bye Laws regulations are adapted for Ammonia bunkering and procedures for licensing bunker vessels.
The governance for ammonia bunkering will have a system-based approach with long term licenses.

Ship to Ship ammonia bunkering will be performed by licensed ammonia bunker operators on approved locations that are defined in the "Ammonia Bunker Map". Terminals will be qualified as "Ammonia Ready Terminal".

Validation Sheet

VS F002 External Safety

General

The national Dutch legislation requires a quantitative risk assessment (QRA) to assure that the risk of operations with dangerous goods is below maximum risk levels for vulnerable objects. An example of vulnerable objects are people who live in the potential impact areas. Although the above regulations are officially not applicable for vessels when the activity is independent of terminals, for ammonia bunker operations POR requires a safety distance to vulnerable objects compliant with the Dutch national legislation.
Under Dutch external safety regulations, "vulnerable objects" such as residential areas may not be exposed to risks from port activities that exceed an individual risk level of 10^{-6} per year.
n the Dutch regulations, vulnerable objects (e.g. residential areas, schools, large offices) may not be exposed to risks from port activities that exceed an individual risk level of 10^{-6} per year. Around the port area a 10^{-6} risk contour is defined, representing the maximum allowable risk level. The cumulative risk from port activities in the port must remain within this contour and may not exceed it.

To define the locations in the port where bunkering can be allowed from an external safety perspective, a bunker map is under development to assure vulnerable objects never will be exposed with a risk higher than the accepted risk level (10^{-6}).

The next sections will provide clarity on how external safety translates into an ammonia bunker map and how external safety is treated within the various PRL's (6, 7, 8 & 9).

Draft bunker map

For the bunkering the risk due to ammonia bunker scenarios is assessed in a comprehensive quantitative risk assessment. contour for different bunker scenarios. Combining this with the 10^{-6} risk level the threshold line shows which locations are suitable for ammonia bunkering from an external safety point of view.
On top of the Quantitative Risk Assessment a Qualitative Risk Assessment was performed to take other considerations into account, like nautical circumstances and the license to operate due to public perception and political willingness.
Locations on the bunker map are assessed for:

- Safety distance to vulnerable objects
- Nautical suitability
- Emergency Response action perspective
- Security aspects
- Political acceptance

The result of above study and process will be shown (PRL 8) in an "Ammonia Bunker Map".

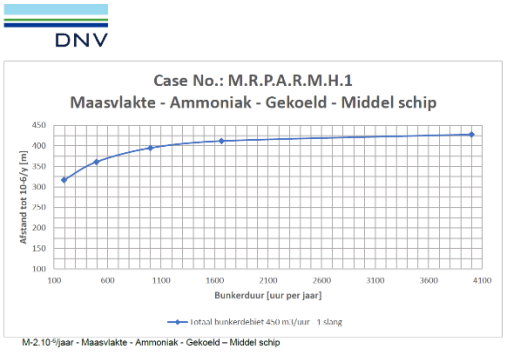
This has already been done for LNG, as shown in the LNG bunker map an example.

For ammonia the final bunker map, which includes all of above topics is still under development.

Pilot - PRL 6

Although the ammonia bunker map isn't finalized, the results of the quantitative risk assessment performed for the development of the bunker map and the decision of the location gives enough information to guarantee sufficient external safety distance to vulnerable objects. For companies and people in the direct vicinity additional safeguards were developed.

For the pilot location, the results from the QRA were used to define the required external safety distance. These were based on the best matching bunker scenario for the evaluated location.



Based on the QRA, a transfer of 450m^3/h of 3 hours will result in a 10^{-6} contour of less than 320 m (the results of the calculation start at 100 h/y). The nearest residential area is at > 6 km distance. To avoid public presence in the vicinity such as on the beach area and at the port information center, the window for the transfer was set between 18:00 and 07:00.

Pilot recommendations

Recommendation 2.1a:
Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia.

Recommendation2.1b:
Stimulate that the transport of ammonia to the Hinterland by inland navigational vessels will be cold ammonia.

See the Validation Sheet 00 "Pilot lessons learned and recommendations

Deployment - PRL 7

For the intermediate period, during which LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7) the following applies:

- An ammonia bunker map – as explained earlier in this validation sheet - will be developed to establish a spatial planning of STS ammonia bunkering. The QRA was performed for several small/medium/large and low frequent/high frequent ammonia bunker scenarios.
- The external safety of a planned bunkering is assured if the location is designated as a location suitable for ammonia bunkering on the ammonia bunker map.
- For each individual application, in case the bunker map doesn't give clearance, a quantitative risk assessment has to be performed to assess the external safety distance of the 10-6 contour related to the planned location
- For each individual application, a qualitative risk assessment will be performed to determine if the location is suitable for the planned bunker scenario. Depending on the location, other authorities such as the EPA will be involved in this QRA.

Deployment - PRL 8 and 9

- For the future bunkering phase, dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8) will be authorized through their license to perform ammonia bunkering at the suitable locations identified by the ammonia bunker map. The terminals, where applicable, must demonstrate adequate right risk awareness and preparedness to ensure safe and compliant operations.
- In case of an application for a location outside the bunker map, or on a location indicated on the bunker map as not suitable, the PRL 7 process will be used.

Validation Sheet

VS F003 Control Zones

General

When conducting ship-to-ship ammonia bunkering in a port, several control zones need to be implemented to ensure safety and to protect the vicinity. For every control zone, a HAZID needs to be performed to set proper risk mitigation.

The key zones and measures during a bunkering pilot are the following:

1. **Hazardous Zone**: (red in the figure)
   The safeguards in this zone are based on possible presence of gas due to operations. Ignition sources are excluded, and personnel are protected (PPE) from toxic sources. Equipment should be suitable and certificated for safe operations in this zone. Gas detection, -measurement and -monitoring should be in place.

   This is the immediate area around the bunkering operation where only essential personnel were allowed wearing PPE.

2. **Safety Zone**: (Orange circle in the figure)

   Surrounding the Hazardous zone, the safety zone is established to protect against the effect of potential leaks or spills.

   Only essential personnel and relevant third parties are allowed if instructed well and, an escape mask for immediate use needs to be standby. This area should be monitored for ammonia concentrations and equipped with emergency response equipment. When Simultaneous Operations SIMOPS) are considered, the required SIMOPS risk mitigation should be arranged based on a risk assessment. The zone needs to be supervised by a responsible officer. Proper risk mitigation should be in place based on a HAZID assessment.

   Proper risk mitigation should be in place to avoid the risk of falling containers or lash materials on the ammonia bunker tanker (dark purple area in the drawing alongside the bunker vessel)

   Proper safety measures should be established for personnel and other people on board of the vessels and on the terminal.

   The threshold to set the safety zone was defined at 220 ppm/half an hour (SGMF).

3. **Monitoring Zone**
   This zone extends beyond the safety zone and is used to monitor activities around the bunker operation. In Rotterdam, VTS will inform vessels at the entry of the port if they are going to pass a bunkering of an alternative fuel.

   The terminal is responsible to monitor other operations outside the safety zone, such as maintenance and visitors, to ensure their presence will not interfere with or pose a risk to the bunkering operation.

4. **Marine safety zone**: (blue in the figure)

This area is designated to establish a safety distance during bunkering between the vessels involved in the bunker operation and passing vessels and moored vessels in the vicinity.
See the validation sheet F005: "Nautical Safety"

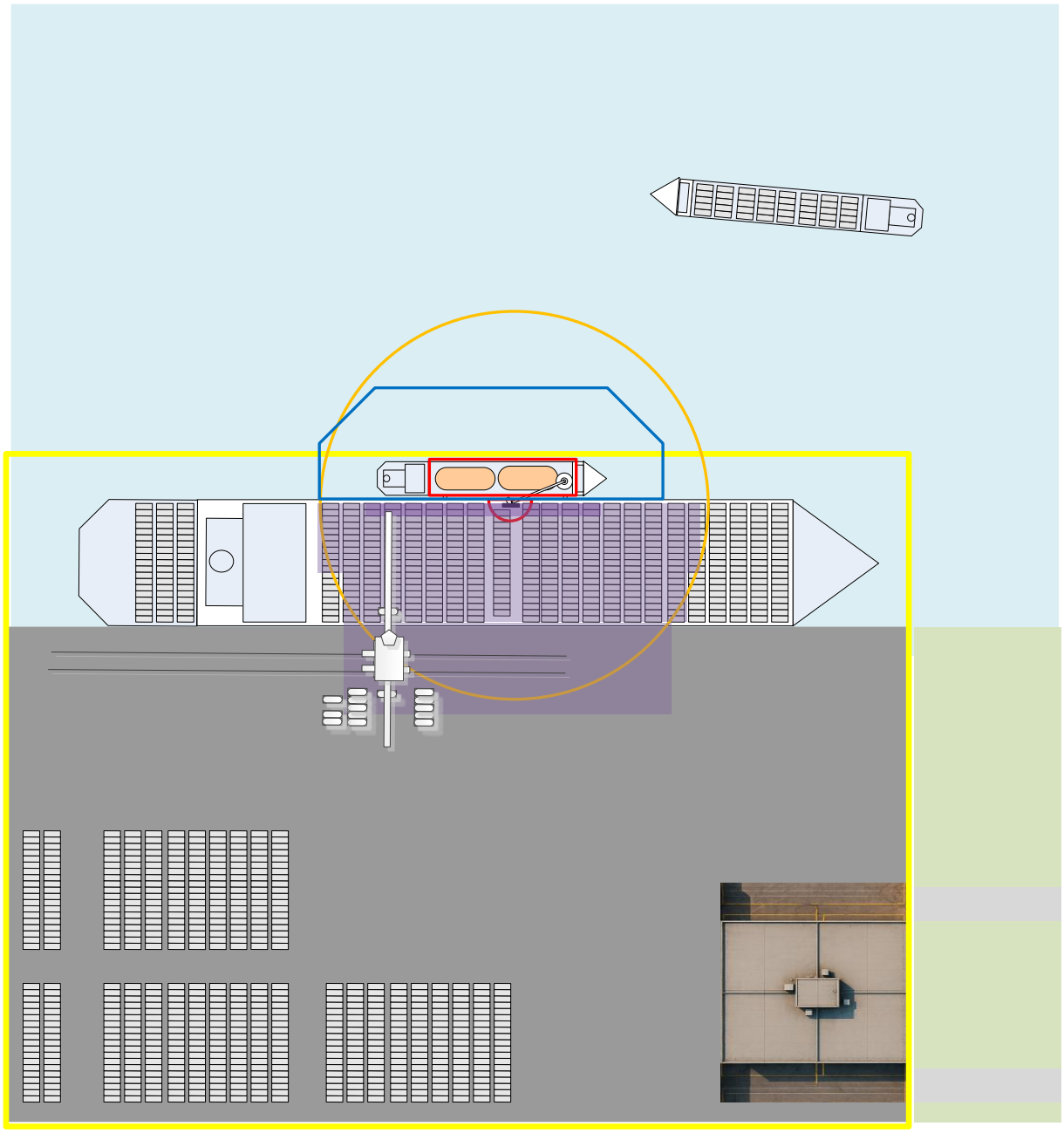
5. **Security zone** (yellow in the figure)

    - The ISPS (International Ship and Port Facility Security) Code requires terminals, where seagoing vessels berth, to establish a dedicated security zone. This ISPS security zone is a controlled area designed to:

        The zone is typically fenced off and access is only allowed to individuals with proper identification and a valid reason to enter such as crew members, port staff, or authorized visitors. Terminals must maintain clear procedures for access control, incident response, and regular security assessments.

6. **External Safety zone**

    - The external safety zone is established to provide an additional layer of protection for the surrounding environment and population. This zone helps to mitigate the impact of any accidental release of ammonia.
        See validation "External Safety"



Pilot - PRL 6

During the pilot, two LPG tankers carrying ammonia were used to perform the ammonia bunker pilot.

1. The **Hazardous zone** during the pilot included the cargo zones of both vessels and the area around the transfer connections. Only authorized personnel wearing PPE during connection, purging, transfer, purging and disconnection.
    - Required PPE: Chemical Suit, Chemical gloves, Chemical safety boots, personal ammonia gas detection, with Emergency Escape Breathing Device (EEBD) and BA sets stand by at the manifold.
    - During gas measuring and disconnection: BA set use required.

    The Hazardous zone in the pilot was based on the pilot JPBO.

2. An **Extra Safety zone** (in addition to the "common" control zones) was established for the pilot. This zone was defined around the manifold, using insights from the gas dispersion study and applying the Dutch threshold of 1101ppm for 1 hour. The boundary was at ca. 175 m.
   Only authorized personnel with Emergency Escape Breathing Device (EEBD) on standby for direct use are permitted, the zone is restricted for other personnel.
   (*Red line in the drawing*)

3. The **Safety zone** during the pilot was established based on a gas dispersion study and the AEL threshold of 220 ppm for half an hour. The boundary was at ca. 470 m. Only instructed and authorized people were allowed. All companies in the safety zone were informed with an information sheet including additional information and contacted to discuss the necessary preparation for a possible effect of a spill or emission. To reduce the number of personnel present at the companies in the safety zone, the window for the transfer was set between 18:00 and 07:00.
   the terminal at the opposite side of the port basin was informed and would assure the vessels alongside not to have an impact on the bunker safety at the other side of the water.
   (*Orange line in the drawing*)

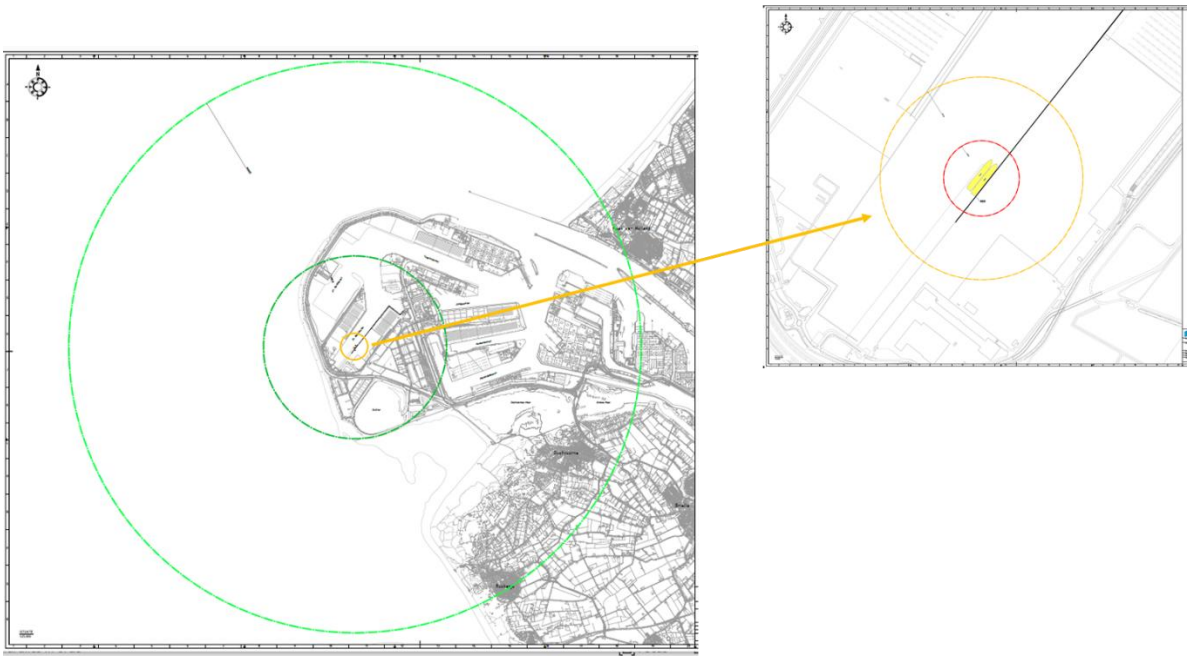
4. The **Monitoring zone** was the whole terminal (fences and a gate secured by security personnel). To reduce the number of construction workers at the terminal in the monitoring zone, the window for the transfer was set between 18:00 and 07:00)

5. The **Marine Exclusion zone** during the pilot was established by prohibiting other vessels from passing the bunker location, super visioned by a patrol vessel of the POR.
   On the quay no other vessels were moored in the vicinity of the ammonia tankers.
   VTS and other vessels were informed by official POR communication for shipping.

6. A pilot specific **Information zone** was established based on a gas dispersion study and the Dutch threshold of 30 ppm for 1 hour. The boundary was defined at 3,2 km, in which we informed companies and municipalities on the planned pilot with an information sheet. To supply the proper information and to reach all relevant people, we used a Strategic Stakeholder Management and Communication approach.
   (*Inner green circle in the drawing*)

See validation sheet I: "Strategic Stakeholder Management"

7. Specifically for the pilot we added an **Awareness zone. This was** based on a gas dispersion study and the odor threshold of 5 ppm. The boundary was at 10 km, in which we informed municipalities on the operation by the information sheet and prepared a protocol in case inhabitants would experience hinderance or have smell complaints.



Pilot recommendations

3.6 Recommendation 3.6
Make sure all pilot relevant personnel, service providers or other third parties are informed upon restrictions and procedures.

See the Validation Sheet 00 "Pilot lessons learned and recommendations

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7):

1. The **Hazardous zone** will include the cargo zones of the LPG tanker acting as ammonia bunker vessel, the area around the transfer connections and the area on the receiving vessel indicated in the Bunker Management Plan as hazardous zone. Only authorized personnel wearing PPE (conform the PPE matrix of the vessels and the Joint Plan of bunker operations) is allowed.

Deployment; PRL 8 & 9

When licensed dedicated ammonia bunker vessels will be used in the port of Rotterdam (Port Readiness Level 8):

1. The **Hazardous zone** will include the cargo zone of the dedicated ammonia bunker vessel, the interface between the vessels and the areas indicated as hazardous zone in the bunker management plan of both involved vessels. Only authorized personnel wearing PPE (conform the PPE matrix of the vessels and the Joint Plan of bunker operations) is allowed.

Deployment - PRL 7, 8 & 9

2. The **Safety zone** surrounds the Hazardous zone, the safety zone is established to protect against the effect of potential leaks or spills. Only essential personnel and relevant third parties are allowed if instructed well and having an escape mask on standby. This area should be monitored for ammonia concentrations and equipped with emergency response equipment. The zone has to be supervised by a responsible officer
    - Proper risk mitigation should be in place based on a HAZID assessment
    - The limits of the safety zone are based on a gas dispersion study of credible leak scenarios, using a threshold of 220 ppm/half hour, as performed for the ammonia fueled vessel.
    - Proper risk mitigation should be in place to avoid the risk of falling container or lash materials on the ammonia bunker tanker
    - Proper safety measures should be established for personnel and other people on board of the vessels and on the terminal
    - In case the safety zone covers a part of the terminal, proper safety measures should be established for personnel and other people on the terminal. The terminal should be prepared to deal with the risk involved.
      (*See validation sheet "Terminal Readiness")*

3. The monitoring zone:
    - See introduction
      (*See validation sheet "Terminal Readiness")*

4. The nautical safety zone:
    - See introduction
      See the validation sheet "Nautical Safety"

5. The security zone:

- See introduction

6. The External Safety zone:
    - See introduction
        See the validation sheet "External Safety"

Validation Sheet

VS F004 Terminal Readiness

General

Ammonia-powered vessels meet strict standards, making them inherently safe, but ammonia properties introduce additional risks for terminals. These risks depend on the ship-to-shore interface, regulatory framework, and planned operations while alongside. Effective coordination between vessel, bunker vessel, and terminal is critical and requires a system-based approach.

Terminal preparations vary by operation type and frequency, but each must demonstrate to the port authority and stakeholders that ammonia-related operations are safe and systematic. Rotterdam supports terminals in obtaining the IAPH "Clean Marine Fuels Ready Terminal" designation, proving readiness for ammonia-fueled vessels under all conditions.

Terminals should manage pre-arrival information exchange (ideally using the OCIMF Marine Terminal Information Booklet) covering fuel on board and planned activities like bunkering. This enables activation of relevant Safety Management System (SMS) procedures.

The IAPH tool guides terminals in achieving readiness for ammonia-fueled vessels across four scenarios:

- Layby berth at the terminal
- Terminal operations without bunkering
- Bunkering without terminal operations
- Terminal operations with bunkering (SIMOPS)

Rotterdam prefers a system-based approach (PRL 8–9) with licensed bunker vessels and designated Clean Marine Fuel Ready Terminals. If a terminal is not prepared, a project-based approach (PRL 7) ensures equivalent safety.

In case an ammonia fueled vessel calls a terminal without ammonia bunkering a preparation is preferred conform the IAPH methodology. To assure the terminal the ammonia fuel installation is in a safe condition, the terminal can use the IAPH "Clean Marine Fuel Terminal Call Checklist".

Pilot - PRL 6

During the pilot, the terminal was not designated as an ammonia-ready terminal. However, APMT is designated as an LNG and Methanol ready terminal and familiar with the SMS procedures that should be executed during bunkering of these fuels such as:

- Terminal alarms and personnel alarm awareness
- Terminal safe escape and evacuation routes
- Communication plans
- Awareness of control zones
- Safety zone risk mitigation
- First Aid and Emergency Response
- Security and a restricted person admission regime
- Etc.

Due to this, many SMS procedures necessary for ammonia bunkering and the Terminal Emergency Plans were already in place although not specific adapted for ammonia bunkering.

For the call of the ammonia tankers alongside and the ammonia bunker pilot, the (above mentioned) procedures were adapted with special precautions for ammonia.
The preparation and terminal procedures were discussed in the pilot preparation work groups.

During the pilot, the vessels were moored alongside a part of the terminal still under construction, and the transfer was performed in a time frame (between 18:00 and 07:00) chosen to minimize the number of terminal personnel or third-party personnel in the vicinity of the vessels. Due to these measures there was a compliance with the terminal safety procedures for operations.

For persons in the vicinity during the transfer, strict safety measures were established.
An Incident Response plan was developed with the Governance team

see validation sheet VS F011 – Port Resilience & Emergency Response -

A safety team of terminal's HSEQ department was involved to assure all necessary terminal preparations were in place during the call of the vessels.

Pilot recommendations

Recommendation 3.3
Establish two exit/evacuation routes or ways of escape on board of the vessels.
Include the information in the JPO and make sure everybody is aware of the means for evacuation.

Recommendation 3.4
Make sure there are always two means of entrance and exit for the emergency response services and two ways of escape for the evacuation of personnel on/via the shore.

Recommendation 3.5
Since all efforts in preparing the barriers for the right side of the Bow Tie is done in three phases, first response by the vessels, second response by the terminal and third response by the shore incident response organization, exchange of each other's capabilities and equipment is essential.

Recommendation 3.6
Make sure all pilot relevant personnel, service providers or other third parties are informed upon restrictions and procedures.

Recommendation 3.7
Make sure all relevant organizations and Operational Managers remain informed on the progress on agreed moments and agreed way during the pilot.

Recommendation 4.13a
Address all expected SIMOPS in the J(B)PO. Make clear what the responsibilities and condition are for SIMOPS.

See the Validation Sheet 00 "Pilot lessons learned and recommendations

Deployment - PRL 7

For the intermediate period, where not all terminals are prepared for a call of an ammonia fueled vessel, or an ammonia bunkering of a vessel alongside, a project base approach will be used to achieve the same high level of safety. The terminal will be involved in the (safety) preparation for the specific call. If necessary, an additional risk assessment, HAZID/HAZOP should be performed, and risk mitigation measures should be implemented for the particular call.

Examples are:

- Preparation by a terminal safety team
- Inform, instruct and train relevant terminal personnel
- Develop and execute a terminal specific communication plan for the call
- Prepare the terminal incident response organization
- Develop a terminal safety plan for the call
- Develop a terminal evacuation plan and establish appropriate means of escape.
- Designate terminal supervisors and involved personnel
- Complete the IAPH Call checklist on board of the vessel

Examples of additions in case of bunkering:

- Assure the terminal and involved personnel can meet the required risk mitigation described in the JPBO of the vessel (SIMOPS, Control zones, etc.)
- Join the pre-operation meeting
- Make an agreement on SIMOPS with the vessel's persons in charge of the vessel
- Complete the IAPH Ammonia bunker checklist (A) together with the persons in charge of the vessels
- Perform repetitive checks conform the ammonia bunker checklist

In case of Truck-to-Ship bunkering (TTS), the activity should be incorporated into the license of the terminal as an 'Terminal Activity".

In case of Ship-to-Ship bunkering alongside the terminal, the ammonia bunker operator should have a license for STS ammonia bunkering. A requirement for approval of the operation in this license is: The terminal should be designated as an "Ammonia Ready Terminal".

If the bunker operator cannot meet the license requirements, or if the bunker operator isn't licensed, the bunker operator can apply for an exemption.
Depending on the call particulars and documents, the competent authority will decide on granting an exemption. In this exemption, the competent authority will add requirements for the terminal as mentioned above.

The IAPH terminal Readiness methodology can provide an insight into preparing a terminal for ammonia bunkering in PRL level 7.

Deployment - PRL 8 and 9

In case of Ship-to-Ship bunkering alongside the terminal, the ammonia bunker operator should have a license for STS ammonia bunkering. A requirement for approval of the operation in this license is: The terminal should be designated as an "Ammonia Ready Terminal". If the bunker operator cannot meet the license requirements, or if the bunker operator isn't licensed, the bunker operator can apply for an exemption. In this case the approval procedure will be project based see PRL 7.

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8):

- Terminals have to use the "Terminal Call Checklist" upon the arrival of the vessel.
- Terminals should comply with the terminal readiness system developed by the IAPH Clean Marine Fuels (CMF) working group
- As part of the bunker vessel licensing framework, bunker operations will only be approved at locations where the terminal is assessed as prepared according to the IAPH Clean Marine Fuels terminal readiness system.

See the IAPH Clean Marine Fuels (CMF) working group CMF website. Products | IAPH

Validation Sheet

VS F005 Nautical Safety

General

At present, ammonia tankers regularly call at Rotterdam–OCI to load and discharge ammonia. In the future, with an expected increase in the number of ammonia terminals, as well as more frequent calls from ammonia tankers and ammonia-fueled vessels, a renewed admission policy will be developed based on a comprehensive risk assessment.

For nautical safety reasons, the policy is that STS ammonia bunkering will not be permitted at locations with elevated nautical risk. Examples included:

- outer corner of water ways,
- maneuvering areas,
- locations with other vessels heading in a 90 degrees course,
- narrow locations with much passing traffic.

The nautical safety is considered taken as one of the input components in the development of the ammonia bunker map – see validation sheet VS F002.

Current nautical safety systems and vessel services, pilotage, VTS, tugs assistance, etc. are assessed as sufficient for the present traffic conditions in the port. Regular evaluation and assessments will be performed to assess if the capacity and employability remains adequate.

Within the port, vessels carrying certain quantities of Dangerous Goods (DG) are required to display the B-flag or red light. Based on Dutch national legislation, other vessels must keep a distance of 50 meters. Inland vessels must display "Two Cones" or two blue lights which indicate to keep a 50 meters distance.

For future ammonia fueled vessels it is important to report to the Harbour master about the quantity of ammonia on board, including:

- the status of the ammonia, liquefied at –33°C, or pressurized,
- the bunker tank type
- the position of the bunker tank on board of the vessel
- the temperature of the ammonia in the bunker tank

The reporting obligation of this information will be integrated into the mandatory reporting requirements for port calls.

Pilot - PRL 6

During the pilot, two LPG tankers carrying ammonia were used to perform the ammonia bunker pilot.

- Both vessels display the B flag and at night the red light due to the regulations for tankers with Dangerous Goods (DG).
- Based on this signaling, the distance for passing vessels is required to be more than 50 meters.

- During the operation no other vessels (except both involved vessels) are allowed alongside.
- Based on a gas dispersion study, a nautical restriction zone is defined. (See validation sheet on control zones)
- During the operation, as an extra pilot specific safeguard, traffic was suspended, no (passing) vessels were allowed within a distance of 100 meters.
- During the operation a Patrol Vessel of the POR was standby to assure the compliance with this restriction.

Deployment - PRL 7

For the intermediate period, when non-dedicated vessels will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), the following aspects are important for the approach:

- The Bunker Map for ammonia – currently under development - provides guidance on where the bunkering can take place under which conditions.
- In case of an increased risk for collision, or mooring issues due to passing vessels, proper risk mitigation should be in place to assure nautical safety.
- Based on a gas dispersion study, a nautical restriction zone is defined. (See validation sheet on control zones).
- The ammonia fueled vessel needs to display the B flag and at night the red light based on the Port Bye Laws
- A seagoing vessel, e.g. an LPG tanker, acting as ammonia bunker vessel needs to display the B flag, and at night the red light, due to the regulations for tankers with DG.
- An inland vessel acting as an ammonia bunker vessel – with the condition that it needs to be cooled ammonia (- 33 °C) - needs to display two cones and at night two blue lights based on European Inland Transport regulations
- Based on this signaling, passing vessels are required to keep a distance of 50 meters.
- During the operation no other vessels (except both involved vessels) are allowed alongside.
- The distance to other berthed vessels should be at least 50 meters from the cargo zone of the vessel acting as an ammonia bunker tanker.
- Passing vessels, although it will be discouraged, may pass controlled on a shorter distance since they only will be a short time within the 50 m distance with a very low probability a spill will occur at the moment of passing.
- VTS will proactively warn passing vessels of the operation to ensure a safe distance is kept.

Deployment; PRL 8 & 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam, the following aspects are important for the approach:

- An ammonia bunker map will be available which indicates which locations are suitable for STS ammonia bunkering, this includes the considerations from a nautical safety perspective. See Validation Sheet VS F002.
- The ammonia fueled vessel has to display the B flag and at night the red light based on the Port Bye Laws.
- A seagoing dedicated ammonia bunker vessel needs to display the B flag and at night the red light, due to the regulations for tankers with Dangerous Goods.

- A dedicated inland ammonia bunker vessel needs to display two cones and at night two blue lights, based on European Inland Transport regulations (ADN)
- Based on this signaling, passing vessels are required to keep a distance of 50 meters.
- During the operation no other vessels (except both involved vessels) are allowed alongside.
- The distance to other berthed vessels should be at least 50 meters from the cargo zone of the dedicated ammonia bunker vessel.
- Passing vessels, although it will be discouraged, may pass on a shorter distance since they only will be a short time within the 50 meters distance with a very low probability a spill will occur at the moment of passing.
- Nautical service providers are aware of the risk involved with the ammonia bunker operation.
- VTS will proactively warn passing vessels of the operation to ensure a safe distance is kept.
- A Marine exclusion zone (nautical control zone) will be applicable with additional requirements for passing vessels. (See validation sheet on control zones).

Validation Sheet

VS F006 Vessel Safety

General

Construction requirements IMO versus Port requirements

The discrepancy between the International Maritime Organization (IMO) construction requirements for ships using new fuels and the requirements due to port conditions is a significant challenge for the maritime industry. Port conditions and requirements are often not taken into account in these guidelines, resulting in a mismatch.

While the IMO has established guidelines for the design and construction of ships using alternative fuels, such as the IGF Code for low-flashpoint fuels, these standards often do not align seamlessly with the infrastructure and safety protocols required in ports. Ports need to adapt their facilities to handle new fuels safely, including bunkering procedures, storage facilities, and emergency response measures. This misalignment can lead to operational inefficiencies and increased costs for shipowners and port operators, highlighting the need for a more integrated approach to regulatory development that consider both ship and port requirements simultaneously.

Examples are:

- Ammonia carriers are, in part, dependent on the safety devices and equipment of the terminal during loading and unloading. For STS transfer between ammonia carriers this terminal equipment is missing, and additional (modular & temporary) equipment is needed. All additional equipment should be certified for an ammonia transfer.
- Ports often impose stricter emission requirements, due to both:
    - The consideration of the operation in light of other operations in the port and the frequency of the operation
    - The vicinity to vulnerable objects and populated areas.
- During loading and unloading of cargo at a terminal, operational emissions (for example due to purging) are minimized by the terminal's vapor processing or vapor recovery equipment. Therefore, IMO does not require this equipment on board of ammonia tankers. However, the terminal equipment is not available in a ship-to-ship setup and alternatives are needed.
- IMO only requires several detection devices on board of an LPG tanker carrying ammonia. For ammonia bunker operations a port will require additional installed and portable monitoring devises and installed and portable measuring and leak detection systems on board of the bunker vessels.
- IMO does have safety requirements for venting and emitted concentrations of ammonia, however, can be smelled at a large distance due to the low odor threshold and the risk of hindrance due to smell, POR guiding principle is zero emission.

PRL 6 - Pilot

During the pilot, two LPG tankers carrying ammonia were used to perform the ammonia bunker pilot.

Vessel specifics:

- Both vessels were classified and flag state certified for the transport of ammonia.
- The vessels were built and equipped conform SOLAS and IGC code.
- Vessels crew was trained conform STCW.
- Procedures on board were conform ISM.

The Compliance with the IMO regulations is checked by Flag State and Port State inspections. Renewal of certificates is done by Class.
Port Enforcements officers check vessels certification at arrival in a port.

Pilot recommendations

Recommendation 2.4a
Be aware that for the use of an LNG bunker vessel as ammonia bunker vessel, time and investment is needed to do the preparation for 100% pilot suitability of the LNG bunker vessel. Aspects of importance are mainly related to possible contamination like
(1) bringing a dedicated bunker tank under ammonia atmosphere taking into account possible LNG and nitrogen (used for purging) contamination with ammonia and
(2) also purging with nitrogen after the operation needs attention to make sure that there will not be contamination of ammonia with nitrogen
(3) Nitrogen in an ammonia bunker tank or ammonia cargo tank will affect the boil off gas management system due to the impact of nitrogen on compression equipment.

Recommendation 3.3
Establish two exit/evacuation routes or ways of escape on board of the vessels.
Include the information in the JPO and make sure everybody is aware of the means for evacuation.

Recommendation 4.1a
When a non-adapted and non-licensed LPG carrier is used for an ammonia bunkering supervision is needed, external, experienced and competence service providers are mandatory for supervision on board. The supervisor should be experienced, competent and aware of in-port bunkering and specific local regulations and requirements for in-port operations such as control zones, SIMOPS, and other operational aspects, or should manage the needed relevant knowledge and expertise.

Recommendation 4.1b
When a, for bunkering equipped and adapted LPG carrier is used on a regular base as an ammonia bunker vessel, crew needs to be experienced, competent and aware of specific local regulations and requirements for in-port operations such as control zones, SIMOPS, and other operational aspects. If knowledge on specific local regulations and requirements for in-port operations is missing, the bunkering should be supervised by an experienced and competent external supervisor.

Recommendation 4.1c
For licensed and dedicated ammonia bunker vessels used for ammonia bunkering in a port, it is essential to ensure – which is being assessed during the audit for the licensing process - procedures are in place to assure personnel involved possess the necessary competence, knowledge and awareness on in-port operations, local regulations, and specific aspects of in-port bunkering, such as control zones, SIMOPS, and other operational aspects.

Recommendation 4.1d
Stimulate training and competence on non-terminal related in-port operations for crew on board of ammonia fueled vessels.

Recommendation 4.1e
Develop training and competence requirements for crew on board of future dedicated ammonia bunker vessels with focus on local regulations and in-port bunker operation specific issues such as control zones, SIMOPS etc.

Recommendation 4.2a
Make sure that for in-port operations appropriate, sufficient, calibrated, tested and operational monitoring/detection equipment/systems are available on board of both involved vessels.

Recommendation 4.2b
Address to IMO and OCIMF that the appropriate monitoring/detection equipment needs to be on board at the right places.

Recommendation 4.3a
Implement in the SMS that all equipment to be used for bunkering needs to be certified for ammonia and checked on certification before transfer to the vessel.

Recommendation.4.7 b
The drip tray shall be sized and positioned to fully cover the area beneath all manifolds pipe or hose connections, with no components protruding beyond its perimeter."

Recommendation 4.8a
For in-port bunker operations the involved vessels should be equipped with means to avoid the discharge of ammonia contaminated water from e.g. drip trays or deck into the harbor water.

Recommendation 4.9a
LPG carriers: For in-port bunker operations using non adapted LPG carriers as ammonia bunker vessel, a system needs to be foreseen – could be modular equipment or knock out drum/tank – where the content of the drip tray should be contained
LPG carriers that are adapted and dedicated for ammonia bunkering should include a retainment or treatment system in their design with the retrofit

Recommendation 4.9b
On both in the ammonia bunkering involved vessels, installed equipment should be in place to empty spilled liquid ammonia from the drip tray into a containment or treatment system e.g. a knock out tank or drums, to avoid uncontrolled evaporation with emission.
Drip trays should have a draining and overflow system so that in case of leakage the ammonia is released into this containment system.

Recommendation 4.15 a
Develop modular VSD / PERC systems of a more compact design. For the time non adapted, non-dedicated LPG tankers will be used for ammonia bunkering, these systems will be mandatory to use for in-port bunker operations. d for the delivery of ammonia bunkers.

Recommendation 4.15 b
For the time non adapted, non-dedicated LPG tankers will be used for ammonia bunkering, means should be developed to make a connection between the modular independent VSD / PERC system and vessel's ESD system. Preferable is the compatibility between the pneumatic, HPU and electric system. Both to be available for 8- and 6-inch connections.

Recommendation 4.15 c
For the time adapted and dedicated LPG tankers, or dedicated ammonia bunker vessels will be used for ammonia bunkering, the vessel separation device and PERC should be (semi) integrated in the vessel's permanent equipment including a (minimal) ESD1 and ESD 2 system.

Recommendation 4.15 d
Use the latest and best available technology when installing VSD / PERC systems

Recommendation 4.16a
Develop proper purging procedures and Ammonia Release Mitigation Systems to establish purging without emission.

Recommendation 4.16b
For process efficiency the parameters for hot gas temperature should be clearly defined for both vessels. It is important that the supplying vessel understands that the reference temperature used to determine when to cease the warm-up process should be taken from the receiving vessel's readings, not from the manifold temperature of the supplying ship.

Recommendation 4.16c
The use of a QCDC or end valve at the receiving manifold could remove the necessity for complete line clearance. Similarly, shorter or lesser diameter liquid hoses would hasten the purging process.

Recommendation 4.20a
Consideration should be given to permitting the purging of liquid hoses (following hot gassing) with air, thus allowing the ammonia/air blend to pass through the vessel GCU. In order to control the flammability hazard introduced thereafter, the ammonia free/air purged hose should be purged and vented to atmosphere with nitrogen/inert gas prior to hose disconnection.

Recommendation 4.20b
Future dedicated bunker vessels should be equipped with a nitrogen generator and storage

Recommendation 4.20c
Future bunker vessels should be equipped with an ammonia release mitigation system

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when, for example, LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam, the following is required on the vessel safety:

- The LPG tanker used as ammonia bunker vessel will be classified and flag state certified for the transport of ammonia.
- The Ammonia fueled vessel will be classified and flag state certified and will have a class approved fuel and propulsion system.
- The LPG tanker will be built and equipped conform SOLAS and IGC code.
- The ammonia fueled vessel will be build and equipped conform SOLAS and ship applicable SOLAS code, the fuel system, engine room etc. will be class approved and compliant with the IGF code.
- Vessels crew is trained conform STCW.
- Procedures on board are conform ISM.
- Supervision of the operation by an external superintendent or Person in Overall Advisory Control (POAC).

Compliance with the regulations is checked by Flag State and Port State. Renewal of certificates is done by class.
Port Enforcements officers check vessels certification at arrival of a vessel in the port

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam the following is required on vessel safety:

- The ammonia bunker vessel will be classified and flag state certified for the transport of ammonia.
- The ammonia bunker vessel will be licensed for bunker operations.
- In case of a seagoing ammonia bunker vessel, it will be built and equipped conform SOLAS and IGC code
- In case of an inland ammonia bunker vessel, it will be built and equipped conform ADN and ES-TRIN.
- The ammonia bunker vessels will have additional equipment based on license requirements:
    - Ammonia Release Mitigation System
    - Contaminated water containment system
    - Knock out tank or equivalent equipment to contain/process spilled cold liquid ammonia
    - Sufficient Nitrogen supply.
- The crew of the ammonia bunker vessel is trained on port specific requirements, control zones, SIMOPS and the SGMF bunker guidance
- The ammonia fueled vessel will be classified and flag state certified and will have a class approved fuel and propulsion system.
- The ammonia fueled vessel will be build and equipped conform SOLAS and ship applicable SOLAS code, the fuel system, engine room etc. will be class approved and compliant with the IGF code
- The ammonia fueled vessels crew is trained conform STCW
- Procedures on board are conform ISM
- The vessels should be capable to purge without emissions.
- The vessels should be capable (sampling possibilities) of sampling without emission conform the agreed Quality Management System.
- Preferably, the bunker vessels will have means for inerting, drying and gassing-up without emission.

Compliance with the regulations is checked by Flag State and Port State inspections or by ILT in case of an inland vessel. Port Enforcements officers check vessels certification.

Validation Sheet

VS F007 Mooring Safety

General

Proper mooring is essential for safe conduct of ammonia bunkering. Industry guidelines from OCIMF and ICS provide key principles for mooring safety, and the OCIMF Mooring Equipment Guidelines, 4th Edition (MEG4) are widely used as the standard for safe mooring practices in many ports.

For ship-to-ship ammonia bunkering, both the ship-shore mooring and the ship-ship mooring should be assessed. Ensuring proper mooring is particularly important because failure of the STS transfer equipment due to vessel movement is a credible spill scenario.

Mooring assurance can be strengthened by using mooring analysis software, such as Optimoor. As an additional safeguard, a vessel separation detection device should be used. This device monitors vessel movements and activate an emergency stop of the transfer (ESD1) or an emergency disconnection (ESD2) if movements exceed the prescribed safe-movement envelope.

The Rotterdam specific regulations for mooring:

Port Bye-laws Rotterdam 2020 (Relevant articles for mooring)

Article 3.4 Proper mooring

1. A vessel is moored properly and safely.
2. If a sea-going vessel is moored longitudinally to another moored vessel, the sea-going vessel of the lengths specified below must maintain the following distances:
    a. up to and including 120 meters; 0.1 x the length of the sea-going vessel with a minimum of 10 meters, or;
    b. longer than 120 meters in length; 0.1 x the length of the sea-going vessel with a minimum of 15 meters and a maximum of 35 meters.

Pilot - PRL 6

Two LPG tankers carrying ammonia were used to perform the ammonia bunker pilot. The following activities took place regarding the proper mooring.

- The mooring and fendering was in accordance with MEG4.
- Mooring and fendering was addressed during the compatibility assessment.
- A mooring study was performed (Optimoor).
- A mooring and fendering plan were established for shore-ship and ship-ship mooring.
- The mooring plan was incorporated in the JP(B)O.

Pilot recommendations

Recommendation 4.15 d
Use the latest and best available technology when installing VSD / PERC systems

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7):

- The mooring and fendering have to follow MEG4.
- Mooring and fendering have to be addressed during the compatibility assessment.
- To arrange the mooring, a mooring study should be performed (Optimoor) by the ammonia fueled vessel.
- A mooring and fendering plan have to be established for shore-ship and ship-ship mooring.
- The ammonia fueled vessel should be properly equipped for mooring of the bunker vessel.
- The mooring plan has to be incorporated in the JPBO.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8):

- The mooring and fendering have to follow MEG4.
- Mooring and fendering have to be addressed during the compatibility assessment.
- To arrange the mooring, a mooring study should be performed (Optimoor) by the ammonia fueled vessel, unless the bunker scenario is known, and a study is performed for a previous bunkering with exactly the same configuration and conditions.
- For dedicated bunker barges, designed for certain mooring scenarios, mooring studies are preferable however, not mandatory.
- A mooring and fendering plan have to be established for shore-ship and ship-ship mooring.
- The ammonia fueled vessel should be properly equipped for mooring of the bunker vessel.
- The mooring plan has to be incorporated in the JPBO.

Validation Sheet

VS F008 Bunker Safety

The validation sheet Bunker Safety addresses several operational bunker safety topics.

Organizational requirements
1. Cold ammonia
2. Compatibility study
3. Joint Plan of Operations (JPO)
4. Third party requirements

Technical requirements
1. Emergency Shut Down (ESD1)
2. Emergency Release of the bunker connection (ESD2)
3. Insulation flange
4. Hose, bunker crane, bunker arm
5. Quick Connect / Disconnect Coupler (QCDC)
6. Leak test
7. Testing of the Emergency Shutdown system
8. Purging procedure without emission
9. Knock-out tank
10. Ammonia contaminated water containment system
11. Decontamination showers, eyewash
12. Contingency and emergency response procedures
13. Personal Protective Equipment, PPE

General

The future requirements to perform a safe ammonia bunkering in Rotterdam are based upon the developed safety framework for bunkering of ammonia and the lessons learned and recommendations of the ammonia bunker demonstration. The points below have been discussed by the validation team and reflect both the pilot's experiences and the Port of Rotterdam's bunker safety requirements for future ammonia bunkering.

Based on the lessons learned during the pilot for above mentioned topics recommendations are included at the topics. On top of the specific recommendations also some general recommendations were made for bunker safety.

General pilot recommendations for Bunker Safety

Recommendation 4.4
Make sure that the length needed for the transfer hoses is such that no flange connections need to be used, and pressure testing is possible.

4.5 Recommendation
Make sure that monitoring of the flowrate is possible

4.6a Recommendation
Incorporate into the purging procedure the recommendation of hot gassing with ammonia including the appropriate requirements to be agreed upon in the JPBO.

4.6b Recommendation
Standardize for in-port operations the acceptable maximum remaining concentration after purging before disconnection in the ammonia bunker transfer line and vapour return line (if used) on max 25 PPM measured at the furthest end from the nitrogen injection point, to avoid hindrance or smell due to the low odor

.

4.6c Recommendation
Consider to incorporate in the purging standard an additional time-period on the remaining concentration of one minute, to be checked by a second measuring after a minute

4.6d Recommendation
Recommend and support adjustment of the MO MSC1- circ 1687 8.5.9. with:

- *Hot gassing*
- *Maximum remaining concentration before disconnection*
- *Method of measuring the remaining concentration before disconnection*

4.7.a Recommendation
The drip tray should be empty, ready for use before commencing the connection of the ammonia transfer hose.

4.7 b. Recommendation
The drip tray shall be sized and positioned to fully cover the area beneath all manifolds pipe or hose connections, with no components protruding beyond its perimeter."

4.8a Recommendation
For in-port bunker operations the involved vessels should be equipped with means to avoid the discharge of ammonia contaminated water from e.g. drip trays or deck into the harbor water

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Organizational requirements

1. *Cold ammonia*:

For Rotterdam, the Ship-to-Ship bunkering of cold ammonia (-33oC) will be the standard. In the preparation phase of the demo, during extensive risk assessments and gas dispersion modeling, cold ammonia had smaller risk contours than pressurized (warm) ammonia. For other bunker scenario's cold ammonia is preferred, for these bunker scenarios bunkering with pressurized ammonia is still under discussion.

Pilot recommendations

2.1a: Recommendation
Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia. Prescribe the use of refrigerated cold ammonia (-33 °C) for bunkering in port areas instead of pressurized ammonia.

2.1b: Recommendation
Stimulate that the transport of ammonia to the Hinterland by inland navigational vessels will be cold ammonia.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

2. Compatibility study

The compatibility assessment during the ammonia bunker pilot is performed conform the STS transfer guide of OCIMF/ICS. Important items, besides the transfer parameters, including the manifold alignment and freeboard differences which are important for the calculation of the length of the activation strings of the vessel separation detection (VSD) device. Specific ammonia transfer items and local specific items were addressed by JF Fendercare.

In the future, the compatibility assessment should be performed compliant to the best practice guidelines of the SGMF and IAPH where ammonia specific issues and port specific issues are addressed systematically for in-port operations.

Pilot recommendations

4.3a: Recommendation
Implement in the SMS that all equipment to be used for bunkering needs to be certified for ammonia and checked on certification before transfer to the vessel.

4.3b: Recommendation
Address hoses, the suitability of the hose, hose certificates and test log during the compatibility assessment prior to the operation.

4.3c: Recommendation
Have a final check on the suitability of the equipment before transfer to the vessel.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

See VS C, Bunker Compatibility assessment

3. Joint Plan of Operations (JPO)

The Joint Plan of Operations used during the ammonia bunker pilot is prepared in line with the STS transfer guide of OCIMF/ICS. The format, for the larger part containing relevant transfer parameters, was sufficient for the pilot.
In the future, the Joint Plan of Bunker Operations (JPBO) format should be used as defined in the best practice guidelines of the SGMF and IAPH, where ammonia specific issues and port specific issues are addressed systematically for in-port operations.

Pilot recommendations

4.10a: Recommendation

- *The operation should be performed in compliance with the JPO and, when possible, depending on pilot scenario JPBO, instructions and therefore should be known by all relevant crew members*
- *All relevant people should participate in the pre-operation meeting.*
- *Address in the pre-operation meeting all agreed (in the preparation phase) transfer and purging parameters.*
- *Adress in the pre-operation meeting local specific items and items relevant for in-port ammonia bunkering.*
- *The PIC of both vessels is responsible that all the relevant crew members are aware of these parameters.*

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

See VS D, JP(B)O

4. Third party requirements

As also described in the Terminal Readiness tool of the International association for Ports and Harbors (IAPH), third parties' personnel should be informed at the gate of the terminal where an ammonia bunkering is planned or ongoing. Admittance on board of the vessels during the bunkering is depending on the result of the SIMOPS study. In many cases visitors will not be allowed to enter the vessels during the bunkering. Third parties' personnel on the terminal should be informed on terminal evacuation signals and plans and should be aware of the risks and risk mitigation measures during the bunkering, e.g. restriction zones.
Requirements for third parties' personnel will be based upon the safety management procedures of the terminal due to the preparation of the terminal for the risks of an ammonia bunkering based upon the Terminal Readiness tool of the IAPH

Pilot recommendations

4.13a: Recommendation

Address all expected SIMOPS in the J(B)PO. Make clear what the responsibilities and condition are for SIMOPS

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

See VS F004, Terminal Readiness

Technical requirements

1. Emergency Shut Down (ESD1)

The ESD system will shut down cargo pumps and close relevant valves when activated by sensors, exceeding parameter limits, or by manual activation. During the ammonia bunker pilot both vessels were equipped with mandatory ESD systems.

Pilot - PRL 6

For the pilot two LPG tankers were used. Since the required ESD connection for LPG tankers between ship and shore for ordinary cargo transfer is a one-way communication, it was not possible to establish a two-way ESD link between the two vessels. An ESD link is a connection between two vessels that arranges, in case of an activation of the ESD system on board of one of the vessels, the activation of the ESD system of the other vessel.
During the pilot, instead of an ESD link, cables with a manual activation device (red button) were exchanged between both vessels.

Deployment - PRL 7, 8 and 9

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam the ESD link will be mandatory for STS ammonia bunkering. Preferably with the SIGTTO link(s). For vessels with another ESD link connection, a multi connection device should be used to establish the ESD link.

2. Emergency Release of the bunker connection (ESD2)

In case of separation of the vessels, it should be possible to perform an emergency disconnection of the transfer system to avoid damage and a spill due to the overstressing of the transfer system. This system can be passive with a dry break away coupling or active with a powered emergency release system (PERC). The system will be triggered by a Vessel Separation detection Device (VSD), by other sensors in the ESD2 system or manual activation. Before the activation of the PERC by an ESD2 signal, the ESD1 should be activated.

Pilot - PRL 6

During the pilot an 8-inch Claw PERC system was used in combination with a VSD. The PERC could be activated manually or by the VSD if, due to a separation of the vessels, the length of the strings was exceeded. One (shorter) string will activate the ESD1, the second (longer) string to activate the ESD2 and PERC. During the pilot the vessels were only equipped with an ESD1 system. The used ESD2 system, including the PERC, was an additional independent modular system. This system was not directly connected to the ESD1 system of the vessels and therefore a procedure was in place to assure that the ESD1 was, in case of an emergency, was activated before the activation of the PERC to make sure that the cargo pumps are shut down and relevant valves are closed.

Pilot recommendations

4.15 a Recommendation
Develop modular VS PERC systems of a more compact design. When the adapted, non-dedicated LPG tankers will be used for ammonia bunkering, these systems will be mandatory to use for in-port bunker operations.

4.15 b Recommendation
For the time non adapted, non-dedicated LPG tankers will be used for ammonia bunkering, equipment should be developed to make a connection between the modular independent VSD / PERC system and vessel's ESD system. Preferable is the compatibility between the pneumatic, HPU and electric system. Both to be available for 8- and 6-inch connections.

4.15 c Recommendation
For the time adapted and dedicated LPG tankers, or dedicated ammonia bunker vessels will be used for ammonia bunkering, the vessel separation device and PERC should be (semi) integrated in the vessel's permanent equipment including a (minimal) ESD1 and ESD2 system.

4.15 d Recommendation
Use the latest and best available technology when installing VSD/PERC systems

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), an active emergency release coupling (PERC) activated by an ESD2 system will be required. If the ESD2 system is an independent modular system, equipment needs to be provided to connect the independent ESD2 system to the ESD1 system, of the vessel. A Vessel Separation Detection Device needs to be installed to activate the ESD2 and PERC.
A hose fall arrestor should be installed to support the hose in case of a PERC activation.

Deployment - PRL 8 and 9

In case of separation of the vessels, it should be possible to perform an emergency disconnection of the transfer system to avoid damage and a spill due to the overstressing of the transfer system. This system can be passive with a dry break away coupling or active with a powered emergency release system (PERC). The system will be triggered by a Vessel Separation detection Device (VSD), by other sensors in the ESD2 system or manual activation. Before the activation of the PERC by an ESD2 signal, the ESD1 should be activated.

During the pilot an 8-inch Claw PERC system was used in combination with a Vessel Separation Device (VSD). The PERC could be activated manually or by the VSD. The VSD is activated if, due to a separation of the vessels, the distance between the vessels exceeds the length of the strings. One (shorter) string activates the ESD1, the second (longer) string activates the ESD2 and PERC. During the pilot the vessels were only equipped with an ESD1 system. Therefore, an ESD2 system, including the PERC, was added as an independent modular system. This system was not directly connected to the ESD1 system of the vessels and therefore a procedure was in place to ensure that the ESD1 was, in case of an emergency, activated before the activation of the PERC. This was done to make sure that the cargo pumps are shut down and relevant valves are closed.

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), an active emergency release

coupling (PERC) activated by an ESD2 system will be required. If the ESD2 system is an independent modular system, equipment needs to be provided to connect the independent ESD2 system to the ESD1 system, of the vessel. A Vessel Separation Detection Device needs to be installed to activate the ESD2 and PERC.
For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), an active emergency release coupling (PERC), activated by a vessel installed ESD2 system, is required. A Vessel Separation Detection Device needs to be installed to activate the ESD2 and PERC. Loss of power on the ESD2 system and PERC should activate the ESD1 system to make sure that the cargo pumps are shut down and relevant valves are closed. Preferred is, a PERC that will close the valves before breaking the connection, or a PERC that will close the valves and will drain and purge the space between the valves into the ARMS system before the powered break of the connection.
The ESD system on board the vessel should minimally have an ESD1 and ESD2 system that assures that an ESD1 is activated before the ESD2 is activated. The ESD systems of both involved vessels should be interconnected by an ESD1 link. A hose fall arrestor should be installed to support the hose in case of a PERC activation.

A passive ERC (dry break away coupling) will not be allowed since a passive ERC system is independent of the ESD1 system of the vessel. It will be activated due to stress on the connection. An active PERC will only be activated before stress on the connection system occurs.

3. Insulation flange

An insulation flange and proper hose handling can avoid electrical arcing during disconnection due to electrical potential differences between the vessels. The probability of ignition is low since a hose will be purged before disconnection to minimize the ammonia vapor release during disconnection and, for ignition of ammonia a high energy source and a certain concentration of air is needed. However, a flammable atmosphere (an air–fuel mixture capable of catching fire when ignited) can occur. The use of an insulation flange will prevent a spark during disconnection that can be an ignition source.

Pilot - PRL 6

During the pilot an insulation gasket with bolts in isolation buses was installed in the bunker hose to prevent electrical arcing from occurring during disconnection. Insulation flanges are not standard equipment of LPG tankers since the insulation flange is integrated in marine (un)loading arms of terminals.

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), equipment need to be provided to avoid electrical arcing during disconnection. It will be required to use an insulation flange or gasket in the transfer line and vapor return line. A bonding cable is not allowed to be used instead of the insulation flange or gasket.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8) equipment to avoid electrical arcing during disconnection, such as an insulation flange, should be integrated in the loading arm of the ammonia bunker vessel. A bonding cable is not allowed to be used instead of the insulation flange or gasket.

4. Hose, bunker crane, bunker arm

Pilot - PRL 6

For the pilot two 18 meter, 8-inch x 150 ANSI cryogenic flexible hoses were used. One for liquid ammonia transfer and one for vapor return. Both hoses should be certified for ammonia/LPG, it took some time to make the proper certificates available. During the preparation it appeared that the liquid ammonia transfer hose was made and therefore certified for LNG transfers. Both products have fundamentally different physical, thermal, and chemical properties. As a result, the design and safety requirements for the hoses also differ Therefore the hose needed to be replaced with a certified LPG hose, also fit and certificated for ammonia. Four (secured) saddles were used to support the hoses. The saddles were also equipped with a hose fall arrestor to support the hose in case of a PERC activation.
The 18 m length of the hose was a hurdle for proper purging.
During the pilot, the vapor line was purged and leak tested with nitrogen, however since the BOG management system (compressor) of the receiving vessel had enough capacity to deal with an increasing pressure due to the bunkering, the valves of the vapor return line remained shut off to be used in case of extreme pressures. During the pilot these extreme pressures didn't occur, the valves of the vapor return line remained closed during the whole operation.

Pilot recommendations

4.11a Recommendation
Use a "one length" hose instead of two connected hoses for the bunkering of ammonia. In case more connected hoses have to be uses, make sure the connections can be leak tested before the start of the bunkering.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, before dedicated ammonia bunker vessels will be used in the port of Rotterdam (Port Readiness Level 7), bunkering will be performed by an LPG tanker without a fixed marine bunker arm. A hose connection will be used. The hoses must be certified for ammonia. The length of the hose should be adjusted for the specific bunkering. Connection of a vapor return line will be mandatory. In case the BOG management system is used to deal with the increasing pressure the valves can remain closed, the vapor return line will act in that case as an additional safeguard. In case of a high bunker rate and/or the capacity of the BOG management system is not sufficient to deal with the increasing pressure, the vapor return line has to be used in an open condition. Justification for allowing a closed vapor return line will be requested as part of the JPBO.

Deployment - PRL 8 and 9

A passive ERC (dry break away coupling) will not be allowed since a passive ERC system is independent of the ESD1 system of the vessel. It will be activated due to stress on the connection. An active PERC will only be activated before stress on the connection occurs. An insulation flange and proper hose handling can avoid electrical arcing during disconnection due to electrical potential differences between the vessels. The probability of ignition is low since a hose will be purged before disconnection to minimize the ammonia vapor release during disconnection, and, for ignition of ammonia a high energy source and a certain concentration of air is needed. However, a flammable atmosphere (an air–fuel mixture capable of catching fire when ignited) can occur. The use of an insulation flange will prevent a spark during disconnection that can be an ignition source.

During the pilot, the vapor line was purged and leak tested with nitrogen, however since the BOG management system (compressor) of the receiving vessel had enough capacity to deal with an increasing pressure due to the bunkering, the valves of the vapor return line remained shut to be used in case of extreme pressures. During the pilot these extreme pressures didn't occur, the valves of the vapor return line remained closed during the whole operation.

For future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), the ammonia bunker vessel should be equipped with a marine bunker arm/crane. The use of a bunker arm or crane with fixed piping reduces the risk of a breach in the transfer system as shown in risk modeling to assess the external risk of the operation. The transfer system will have an installed insulation gasket, PERC and fall arrestor. The bunker arm should also be equipped with a vapor return line.
In case the bunker arm/crane cannot be used, hoses can be used, however, then the PRL 7 requirements will be applicable.

5. Quick Connect / Disconnect Coupler (QCDC)

A Quick Connect/Disconnect Coupling (QCDC) used in a Ship-to-Ship (STS) ammonia bunkering is a specialized device designed to reduce the time needed for making a manifold connection. The fast connection is established by installing a (mother) part at the manifold of the receiving vessel and a (father) part on the end of the transfer hose (and vapor return hose). The QCDC is equipped with end valves that will be open when connected and closed when disconnected. It offers the possibility to keep the hose in ammonia vapor condition after disconnection, and only the connection space between the valves has to be purged before disconnection.
Some types of QCDC also have emergency release functionality.
Due to the weight, the handling of the QCDC of larger bunker line diameters is more difficult.

The use of a QCDC will make the connection more efficient. However, if the devices on board of both vessels have to be installed and deinstalled for every bunkering, this will add to the preparation time on the vessels.

Pilot - PRL 6

During the pilot a flange connection was used.

Pilot recommendations

4.16c Recommendation
The use of a QCDC or end valve at the receiving manifold could remove the necessity for complete line clearance. Similarly, smaller-diameter or shorter liquid hoses would speed up the purging process.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers still will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), both flange connections and QCDC connections are allowed. However, as long as not all receiving vessels are equipped with the same (mother) part of the QCDC, the (father) part of the QCDC on board of the discharging LPG tanker should be uninstalled from the hose every time another connection is used.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), both flange connections and QCDC connections are allowed. The QCDC connection is preferred when it is accepted that the transfer line can remain under an ammonia vapor atmosphere, since that will reduce the purging of the line before disconnection.

6. Leak test

Before the transfer commences, leak tests should be performed by pressurizing the connected lines with nitrogen. The pressure should be maintained in the line (without adding additional nitrogen) to show there are no leaks. Once the leak test is completed, the nitrogen pressure can be released to the atmosphere. Other leak tests can be performed with suitable (portable) gas detection devices. A water soap mixture also can be used, although with a cold system the water will freeze. When using a water soap mixture for leak testing a QCDC, this introduces the risk of leakage due to ice on the seals (according to the Original Equipment Manufacturer (OEM)).

Pilot - PRL 6

Before the transfer commences, leak tests should be performed by pressurizing the connected lines with nitrogen. The pressure should be maintained in the line (without adding additional nitrogen) to show there are no leaks. Once the leak test is completed, the nitrogen pressure can be released to the atmosphere. Other leak tests can be performed with suitable (portable) gas detection devices. A water soap mixture also can be used, although with a cold system the water will freeze. When using a water soap mixture for leak testing a QCDC, this introduces the risk of leakage due to ice on the seals (according to the Original Equipment Manufacturer (OEM)).

During the pilot, after connection, a warm pressure test with nitrogen was performed. Liquid line 7 bar, vapor line 2 bar. No detected leakage.

During the transfer, leak detection was based on portable gas measurement devices. However, on one of the vessels only detection tubes were available. This was solved by supplying the vessel with an additional portable measurement device.
One of the connections in the line could not be reached (positioned outboard) for a leak test.

Pilot recommendations

4.11a Recommendation

Use a "one length" hose instead of two connected hoses for the bunkering of ammonia. In case more connected hoses have to be uses, make sure the connections can be leak tested before the start of the bunkering.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), a leak test, by pressuring the hoses after connection, with nitrogen will be required. Involved vessels will be required to be able to do leak detection by a fixed or portable monitoring and measurement system. A leak test measuring protocol should be implemented with prescribed "Leak is Stop" authority. A sufficient number of gas detection devices should be on board for personal protection and leak and process measurements

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), a leak test by pressuring the connections with nitrogen will be required. A leak test measuring protocol should be implemented with prescribed "Leak is Stop" authority. A sufficient number of gas detection devices should be on board for personal protection and process measurements. Receiving vessels will be required to be able to do leak detection by fixed or portable monitoring and measurement devices. The bunker vessel should be able to do leak detection by fixed and portable monitoring and measurement devices.

7. Testing of the Emergency Shutdown system:

Pilot - PRL 6

During the pilot a test of the ESD 1 was performed in warm conditions.
Since, for a cold test, the transfer hose first has to be cooled down by liquid ammonia transfer and a cold test of the ESD1 will introduce additional risk. Therefore, a cold test was not carried out, although it was prescribed in the JPO.
To perform a controlled closure of the manifold, - avoiding excessive pressure surges, the closing time of the manifold valves in case of an ESD1 is approximately 25-28 seconds.

The vessels used an ESD pendant instead of an ESD link. The ESD pendants (exchanged cables with red ESD buttons) were tested during the warm ESD test.
The ESD2/PERC system used during the pilot was an independent modular system. The system was tested in warm conditions in safe (non-activated) mode. Since the PERC device was warmed by the recirculation of the hydraulic oil for the PERC operation, and additional risk would be introduced if the PERC had to be changed from armed mode into a safe test mode, a cold test of the ESD2/PERC wasn't performed. An ESD2/PERC system has to remain armed/life at all times.

Deployment - PRL 7

The system was tested in warm conditions in safe (non-activated) mode. Since the PERC device was warmed by the recirculation of the hydraulic oil for the PERC operation, and additional risk would be introduced if the PERC had to be changed from armed mode into a safe test mode, a cold test of the ESD2/PERC was not performed.

For the intermediate period, before dedicated ammonia bunker vessels will be used in the port of Rotterdam (Port Readiness Level 7), an LPG tanker will be used as an ammonia bunker vessel.

For the involved vessels it will be required to perform a:

- warm ESD1 test before the start of the cooling down of the line;
- cold ESD1 test after the cooling down and before the start of the bunkering;
- warm ESD link test before the start of the cooling down of the line;
- warm ESD2/PERC test (in not live status), before the start of the cooling down of the line.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8).

For the involved vessels it will be required to perform a:

- warm ESD1 test before the start of the cooling down of the line;
- cold ESD1 test after the cooling down and before the start of the bunkering;
- warm ESD link test before the start of the cooling down of the line;
- warm ESD2/PERC test (in safe, nonactivated status) before the start of the cooling down of the line.

8. Purging procedure without emission

For a safe disconnection of a bunker hose or bunker arm, the line must be drained and purged. The first step is always to make sure the connection is free of liquid. This can be established by draining, followed by purging with heated (up to 40°C) ammonia vapor to purge the. in the hose remaining, liquid ammonia into the bunker tank of the receiving vessel, or more commonly back to the tanks of the bunker vessel. The heated ammonia is produced with a heat exchanger on board one of the vessels. To fasten the evaporation process in case of a hose connection, firewater from a fire hose can be used to spray on the lower "U" bend of the hose.

After the liquid ammonia is removed from the transfer system, the hose or arm will be purged with nitrogen to reduce the concentration ammonia vapor in the transfer system to make a safe disconnection possible. Due to the effect nitrogen will have on most of the BOG management systems (these systems will not work properly when they have to process ammonia vapors mixed with nitrogen), purging with nitrogen towards a bunker tank or tank of the bunker vessel is not possible. The release of the gas mixture due to purging into the atmosphere is not allowed in the Port of Rotterdam.

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the evaporation process in case of a hose connection, firewater from a fire hose can be used to spray on the lower "U" bend of the hose.
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In case purging to a bunker tank or back into the bunker vessel, is not possible, means should be provided to contain or process these vapors. Some options to perform purging without emission of ammonia is the use of an ammonia release mitigation system (ARMS), such as a Vapor Recovering Unit (VRU), a Vapor Processing or Combustor Unit (VPU or VCU), a (Catalytic) Scrubber (VCS) or simply a large empty tank for containment of the purged ammonia/nitrogen mixture. This last option is not preferred. It will avoid the emission of nitrogen/ammonia vapor in the port. However, the tank has to be brought back to ammonia atmosphere later.

In case the vapor return connection was used for vapor balancing, the return line also has to be purged with nitrogen before disconnection without emission or causing nuisance due to the smell.

The bunker transfer line and the vapor return line (if used) should be properly purged to enable a safe disconnection without causing smell or hindrance due to the low odor threshold.
In IMO MSC1-circ 1687 the only functional requirements included are:

- *8.5.1 An arrangement for purging fuel bunkering lines with inert gas should be provided"*
- *8.5.5 Means should be provided for draining any fuel from the bunkering pipes upon completion of operation.*
- *8.5.6 Bunkering lines should be arranged for inerting and gas freeing. Means to confirm the absence of residual liquid should be provided. When not engaged in bunkering, the bunkering pipes should be free of gas, or residual liquid, unless the consequences of not gas freeing are evaluated and approved by the Administration*
- *8.5.9 Sampling valves, if fitted, should be arranged at suitable locations in the bunkering line to allow verification procedures to confirm that the bunkering line is safe before opening any flanges. A double shut-off, blank flange or plug should be installed on sampling valves in the bunkering line*

Acceptable limits of remaining concentration after purging before disconnection are prescribed in the vessels SMS bunker procedures. 200 PPM is a commonly used value. These are safety limits to protect the crew, although the crew working on the manifold will wear proper PPE. However, the maximum concentration set in the port requirements are due to the low odor threshold and are lower than the acceptable limit for safety.

During the pilot the maximum concentration was set on 200 ppm. This is close to the Dutch Intervention value "alarm threshold" of 198 ppm with exposure duration 60 min. This is comparable with the US AEGL 2 220 ppm with exposure duration 30 min.

The best practice guidance of the SGMF states the recommendation of 25 ppm.
"*Purging/inerting is considered and it will be achieved when sampling at the furthest end from the nitrogen injection point measures no more than 25ppm (0.0025% vol) Ammonia*".

For licensed and dedicated bunker vessels and, if technically possible, for all other bunker vessels, with the current knowledge, the port will require a concentration of 25 ppm or less, of remaining concentration after purging before disconnection of the bunker transfer line and vapor line (if used)

PRL 6 - Pilot

Means used:
- The hot gas for hot gassing was produced by a compressor in hot gas mode on board of one of the vessels
- The hot gassing with warm ammonia vapor was done towards the ammonia tank of one of the vessels
- Nitrogen was supplied from nitrogen cylinders.
- An empty deck tank on one of the vessels was used as ARMS to collect the ammonia / nitrogen mixture during purging with nitrogen, to avoid emission and to avoid nitrogen coming into an ammonia tank.

Once the liquid ammonia transfer was completed, the remaining liquid in the hose was drained back into the receiving vessel. The lower U-bend of the hose was sprayed with water to help evaporate any trapped liquid ammonia.

After preparations, hot gassing began, with instructions to keep both manifolds below 40 °C due to the hose's temperature limit. After the initial hour of hot gassing, one manifold had warmed sufficiently, but the other remained too cold, so the process continued until both reached the target temperature.

Hot gassing then stopped and nitrogen purging began. The first ammonia measurements after purging were still above 500 ppm, while the required level for disconnection was below 200 ppm. Further checks revealed residual liquid ammonia trapped between the manifold valve and the ESD valve. This was removed, and hot gassing and purging were repeated.

Two hours after the initial measurement, the ammonia concentration was still too high, requiring additional purging. After another hour, both sides finally reached approximately 180 ppm, allowing the hose to be safely disconnected—after in total about six hours of hot gassing and purging.

The vapor return line was not used for the vapor balancing, and didn't contain any ammonia, no need for hot gassing or purging before the disconnection.

Pilot recommendations

4.16a Recommendation
Develop proper purging procedures and Ammonia Release Mitigation Systems to establish purging without emission.

4.16b Recommendation
For process efficiency the parameters for hot gas temperature should be clearly defined for both vessels. It is important that the supplying vessel understands that the reference temperature used to determine when to cease the warm-up process should be taken from the receiving vessel's readings, not from the manifold temperature of the supplying ship.

4.20a Recommendation
Consideration should be given to permitting the purging of liquid hoses (following hot gassing) with air, thus allowing the ammonia/air blend to pass through the vessel GCU. In order to control the flammability hazard introduced thereafter, the ammonia free/air purged hose should be purged and vented to atmosphere with nitrogen/inert gas prior to hose disconnection.

4.20b Recommendation
Future dedicated bunker vessels should be equipped with a nitrogen generator and storage *Future dedicated bunker vessels should be equipped with a nitrogen generator and storage.*

4.20c Recommendation
Future bunker vessels should be equipped with an ammonia release mitigation system.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers still will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), hoses will be used for ammonia bunkering. Procedures should be in place in the Joint plan of Bunker Operations for proper draining, hot gassing and purging. Relevant crew and officers should be acquainted with the JPBO and experienced in STS transfer by hose.

Means should be provided:

- Supervision should be performed by an experiences service provider (Mooring master/POAC).
- Assure free flow of any liquid in the line to prevent over pressurization due to boil of gas (BOG) in the lines.
- Assure purging without emissions by an "Ammonia Release Mitigation System (ARMS).
- Assure sufficient supply of hot gas.
- Define maximum temperature of hot gas due to hose limitations.
- Temperature measurement on both sides of the hose.
- A sufficient (capacity and pressure) supply of nitrogen.

- Define the procedure for nitrogen purging including pressure and time.
- Measure the remaining ammonia concentration in the hose after purging.
- Assure the remaining ammonia concentration in the hose before disconnection <25ppm.
- For process efficiency the parameters for hot gas temperature should be clearly defined for both vessels.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), a bunker arm needs to be used for ammonia bunkering with the bunker valve as close to the manifold of the receiving vessel as possible. Meaning that only a short hose for the connection, or the inter-valve space of the QCDC should be purged. Procedures should be in place in the Joint plan of Bunker Operations for proper draining, hot gassing (if necessary) and purging. The bunker arm should also be equipped with the vapor return line. The bunker arm should be equipped with a Powered Emergency Release System including a fall arrestor and an insulation flange.
Means should be provided to:

- assure free flow of any liquid in the line to prevent over pressurization due to boil of gas (BOG)in the lines;
- assure purging without emissions;
- assure the remaining ammonia concentration in the hose before disconnection <25ppm.

The ammonia bunker vessel should be equipped with:

- an "Ammonia Release Mitigation System (ARMS) such as a Vapor Recovering Unit (VRU), a Vapor Processing or Combustor Unit (VPU or VCU) or a (Catalytic) Scrubber (VCS);
- equipment to deliver sufficient supply of hot gas;
- temperature measurement sensor at the delivery side of the arm;
- equipment to deliver a sufficient (capacity and pressure) supply of nitrogen;
- ammonia concentration measurement sensor at the delivery side of the arm after de valve to measure the remaining concentration of ammonia in the connection hose or inter-valve space of the QCDC before disconnection;
- For process efficiency the parameters for hot gas temperature should be clearly defined for both vessels.

9. Knock-out tank

A spill of liquid ammonia needs to be contained on board, flushing overboard of the spill into the harbour water is prohibited. Using water on spilled liquid ammonia will increase the evaporation rate of the spilled ammonia and will create large emissions. For containment of a larger spill of liquid ammonia in the drip tray or other open containment systems, means should be provided to pump the (cold boiling) liquid to a for example "knock-out" tank to remain contained without emission. The BOG of the slow evaporating liquid ammonia in the knockout tank can be processed in the ammonia release mitigation system.

Pilot - PRL 6

During the pilot no means were available to transfer a possible amount of ammonia from the in the drip tray contained liquid spilled ammonia, to a deck tank to act as knock-out tank.

Pilot recommendations

4.9a Recommendation
LPG carriers: For in-port bunker operations using non-adapted LPG carriers as ammonia bunker vessel, a system needs to be foreseen – could be modular equipment or knock out drum/tank – where the content of the drip tray should be contained
LPG carriers that are adapted and dedicated for ammonia bunkering should include a retainment or treatment system in their design with the retrofit.

4.9b Recommendation
On both of the ammonia bunkering involved vessels, installed equipment should be in place to empty spilled liquid ammonia from the drip tray into a containment or treatment system e.g. a knock out tank or drums, to avoid uncontrolled evaporation with emission.
Drip trays should have a draining and overflow system so that in case of leakage the ammonia is released into this containment system.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), preferred is to:

- have modular equipment or deck tank available to act as a knockout tank;
- have on board means to transfer contained liquid spilled ammonia to modular equipment or a deck tank.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), the bunker vessel should be equipped with:

- an Ammonia liquid Release Containment Treatment System (ARCTS) such as a knockout tank;
- means to transfer contained liquid spilled ammonia to the knockout tank;
- means to process the BOG from the liquid ammonia in the knockout tank.

10. Ammonia contaminated water containment system

Ammonia tankers and ammonia fueled vessels will be equipped with water spray systems based on the IGC or IGF code. In addition, additional water screens system can be installed as "Toxic gas cloud mitigation systems". Due to the excess of water in case of activation due to a spill, most of the water might be flushed overboard.

In a regular process, water can retain on board in containment systems such as drip trays or on deck when the scuppers are closed. In case of a small spill or emission (ammonia is hygroscopic) the water will be contaminated with ammonia. To check if water is contaminated, a simple pH test can be used.
If water is contaminated with ammonia, it is prohibited to drain overboard or open the scuppers.
If scrubbers are used in the process to avoid emissions of ammonia, this also will result in ammonia-contaminated water.
Contaminated water can be discharged via liquid waste collection tankers to port reception facilities or can be discharged for utilization, if the purity is high enough.
Another option is to have a contaminated water processing plan for neutralizing the contaminated water.

Pilot - PRL 6

During the pilot no means were available to contain contaminated water collected in drip trays or on deck with closed scuppers. However, there was no contaminated water produced.

Pilot recommendations

4.8a Recommendation
For in-port bunker operations the involved vessels should be equipped with means to avoid the discharge of ammonia contaminated water from e.g. drip trays or deck into the harbor water.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), discharge of ammonia contaminated water is prohibited. A dedicated containment system for ammonia contaminated water on board of the receiving ammonia propelled vessel or the LPG tanker acting as bunker vessel is preferred. IGF-and IGC rules will require a containment capacity for contaminated water on board of the vessels that can be used to avoid that ammonia contaminated water will be drained or flushed overboard in the port.
Scuppers should be closed during the stay in the port, (clean) water on deck can only be drained after demonstration on the basis of an analysis which proves the water is free of ammonia and the water is checked on other contaminations.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), as a requirement in the license, the bunker vessel should be equipped with a dedicated containment system for ammonia contaminated water. A dedicated containment system on board of the receiving vessel is preferred but not required by the Port Bye Laws.

Scuppers should remain closed during the stay in the port, (clean) water on deck can be drained after demonstration on the basis of an analysis which proves the water is free of ammonia and the water is checked for other contaminations. Polluted water needs to remain on board or can be discharged to a waste collection barge of a reception facility.

11. Decontamination showers, eyewash

One or more clearly marked showers and eye wash stations shall be provided on deck of all involved vessels. These facilities shall be arranged to suit the size and layout of the ship and shall be capable of operating in all weather and temperature conditions

Purpose and necessity

- *Immediate decontamination:* These facilities allow crew members to quickly wash off hazardous chemicals or liquefied gas residues after accidental exposure, reducing the risk of severe burns, eye damage, or poisoning.
- *Compliance with safety standards:* They are a critical part of emergency response measures required by international regulations for seagoing gas carriers. It's not clear these facilities are (yet) required based upon international regulations for inland navigational vessels or ammonia fueled vessels.

- Protection of life and health: Quick access to showers and eye wash stations can prevent long-term injuries and fatalities.

Measures to ensure these facilities are always ready for use with the following conditions

- *Weatherproof design*
  - Use insulated and heated piping to prevent freezing in cold climates.
  - Ensure materials can withstand corrosive marine environments.
- *Regular inspection and testing*
  - Perform functional checks at defined intervals.
  - Verify water flow, temperature, and pressure.
- *Clear marking and accessibility*
  - Install visible signage and lighting for easy identification
  - Keep pathways unobstructed at all times.
- *Maintenance and spare parts*
  - Maintain an inventory of critical spare parts (valves, nozzles).
  - Schedule preventive maintenance to avoid unexpected failures.
- *Crew training*
  - Train personnel on the location and proper use of these facilities during drills.
  - Include procedures in the ship's safety management system.

Pilot – PRL 6

Since two LPG tankers were used during the pilot, decontamination showers and eye wash station were available, required by international regulations for seagoing gas carriers (IGC).

Deployment – PRL 7, 8 and 9

Decontamination showers and eye wash stations will be required for LPG tankers used as ammonia bunker vessel, and dedicated ammonia bunker vessels.
For ammonia fueled vessels these facilities will not (yet) be required by the POR, since international requirements on this subject for ammonia fueled vessels are not finally established yet, but the availability of these facilities on board of ammonia fueled vessels is strongly recommended by class societies.

12. Contingency and emergency response procedures

Contingency procedures on board seagoing vessels are essential for ensuring safety and preparedness in case of emergencies. The procedures, training and drills are mandatory, based on SOLAS, ISM and MARPOL.
For the ammonia bunkering activity, based on risk assessment, specific contingency and emergency response plans should be developed. This preparedness needs to be performed by both involved vessels due to SOLAS, ISM and MARPOL. The contingency / emergency response plans should be exchanged between both vessels to assure the vessels are acquainted with the plans and action perspective of the other vessel in case of an emergency. The relevant contingency and emergency response procedures should be noted in the Joint Plan of Bunker Operations (JPBO).

Pilot - PRL 6

During the pilot the JPO stated: "Both vessels follow their emergency response plan (ERP) in accordance with their standard operation in dealing with emergency situation". In case of an emergency the vessels crews will be the first responders. Ways to escape / evacuate were indicated in the JPO. Communication lines and contact information between the vessels and external incident responders were defined in the JPO based on the Incident Response plan. In case of an emergency (spill or emission), the task of the vessels crew is to evacuate all persons to a safe area and stop the outflow or reduce the outflow as much as possible. During the pilot a manifold water spray system was available, and fire hoses were stand by.
On board of the vessel the SOLAS required foam system was lined up and standby. However, specialists have different opinions on the effectiveness of foam during an ammonia incident.

The united Rotterdam emergency responders developed an incident response plan and communication plan in case of an emission that can lead to odor nuisance. A firefighting (fifi) patrol vessel of the Port of Rotterdam was on standby during the transfer. To avoid passing vessels during the transfer, the maritime traffic in the port basin was suspended.

Pilot recommendations

3.3 Recommendation
Establish two exit/evacuation routes or ways of escape on board of the vessels. Include the information in the JPO and make sure everybody is aware of the means for evacuation.

3.4 Recommendation
Make sure there are always two means of entrance and exit for the emergency response services and two ways of escape for the evacuation of personnel on/via the shore.

3.5 Recommendation
Since all efforts in preparing the barriers for the right side of the Bow Tie is done in three phases, first response by the vessels, second response by the terminal and third response by the shore incident response organization, exchange of each other's capabilities and equipment is essential.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment - PRL 7

The united Rotterdam emergency responders developed an incident response plan and communication plan in case of an emission that can lead to odor nuisance. A firefighting (fifi) patrol vessel of the Port of Rotterdam was on standby during the transfer. To avoid passing vessels during the transfer, the maritime traffic in the port basin was suspended.
For the intermediate period, when LPG tankers will be used as ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 7), in case of an emergency, the vessel crew will be the first responders.

- Two evacuation routes should be arranged and acquainted by personal on board of the vessels.
- Contact information and means to assure a direct communication with the terminal and external emergency response organization should be available.
- Receiving ammonia fueled vessels should be equipped with containment systems for spilled liquid (cold) ammonia and an ammonia (vapor) release mitigation system.

Involved vessels should have a:
- Fire control plan
- Liquid gas spill control plan
- Toxic gas dispersion control plan
- Emergency Response procedures
- Contingency planning

Port's emergency response organization needs to be prepared for ammonia incident response.

Deployment - PRL 8 and 9

For the future bunkering by dedicated ammonia bunker vessels in the port of Rotterdam (Port Readiness Level 8), based on SOLAS, vessels will have trained crews on contingency plans for ammonia incidents. In case of an emergency the vessels crew will be the first responders. Two evacuation routes should be arranged and acquainted by personal on board of the vessels. Contact information and means to assure a direct communication with the terminal and external emergency response organization should be available and noted in the JPBO. Both vessels should be equipped with containment systems for spilled liquid (cold) ammonia and an ammonia (vapor) release mitigation system. Involved vessels should have a:
- Fire control plan
- Liquid gas spill control plan
- Toxic gas dispersion control plan
- Emergency Response procedures
- Contingency planning

Dedicated ammonia bunker vessels should have the knowledge how to apply a water spray system to decrease the ammonia cloud due to a spill or emission.

See VS F011, Port resilience and Emergency Response preparedness

13. Personal Protective Equipment, PPE

Which protective clothing and equipment is needed should be identified by a risk assessment. PPE shall comply with an approved standard and should be worn by all personal engaged in operations identified in the risk assessment.

Pilot - PRL 6

The Port's emergency response organization has to be prepared for ammonia incident response. Which protective clothing and equipment is needed should be identified by a risk assessment. PPE shall comply with an approved standard and should be worn by all personal engaged in operations identified in the risk assessment.

Pilot - PRL 6

During the pilot all crew and superintendents attending the manifold during connection / disconnection shall comply with an approved standard with the minimum PPE as required below:
- Chemical suit
- Chemical gloves
- Chemical Safety boots
- Personal ammonia gas meter
- Two Emergency Escape Breathing Devices (EEBD) standby at the manifold
- During disconnection: BA sets

Deployment - PRL 7, 8 and 9

The PPE to be available conform the approved standard and worn should be conform the PPE matrix that needs to be on board of both vessels conform the ISM code.
For third parties on board of the vessels, like terminal representatives, visitors, service providers, surveyors, cargo securing teams, etc., that have a role within the safety zone during bunkering, a sufficient number of Emergency Escape Breathing Device (EEBD) should be standby for direct use.

Third party personnel on board in the safety zone without proper personal ammonia measurement devices should be accompanied with ship personnel wearing a personal ammonia detection meter.

Validation Sheet

VS F009 Simultaneous Operations

General

Simultaneous operations (SIMOPS) refers to the execution of multiple activities at the same time. In the context of ammonia bunkering, it indicates that while the bunkering operation is taking place, another activity is ongoing at the same time. Most commonly, this is assumed to be a cargo operation (loading or unloading), but it can also refer to any other activities occurring during ammonia bunkering – such as maintenance, repairs or crew changes. Conducting these activities simultaneously can increase the overall risk level due to additional hazards, such as:

- Introduction of ignition sources within the safety zone.
- Increased presence of people in the vicinity of the bunkering area.
- Risk of falling objects or material impacting critical equipment.

For managing the possible increase of risk due to SIMOPS, the Rotterdam Port Bye Laws only allow SIMOPS if:

- A SIMOPS risk assessment is performed by the ammonia fueled vessel operator, which must include:
  - Defined credible leak scenarios based on the vessel's specific bunkering configuration.
  - A gas dispersion study to determine the safety zone for the vessel's specific bunker configuration.
  - Identification of possible simultaneous operations (SIMOPS) that may take place during bunkering.
  - A HAZID / HAZOP to identify additional risk mitigation measures related to SIMOPS. This should address:
    - hazards posed by the bunkering operation to personnel and activities within the safety zone, and
    - the potential impact of simultaneous operations on the safety of the ammonia bunkering process or the ammonia bunker vessel (e.g., risk of dropped objects).
  - The safety zone and required risk mitigation as defined in the SIMOPS risk assessment must be incorporated into the bunker management plan (BMP) of the ammonia fueled vessel.
- The ammonia bunker vessel operator must follow the same process and incorporate the defined control zones, including the safety zone, and the required SIMOPS risk mitigation measures into the bunker management plan (BMP) of the ammonia bunker vessel.
- During the compatibility assessment, the safety zone, other control zones and all SIMOPS risk mitigation measures from both vessels' BMPs – together with the terminal requirements and local conditions – are consolidated into the Joint Plan of Bunker Operations (JPBO).

- The terminal should be prepared for Ship-to-Ship ammonia bunkering alongside the berth and must be able to meet the vessels' SIMOPS risk mitigation measures defined in the Joint Plan of Bunker Operations (JPBO). If, during the terminal preparation phase, the safety assessment identifies additional terminal-specific SIMOPS requirements, these must be incorporated into both the compatibility assessment and the JPBO. See: the IAPH/CMF Terminal Readiness tool.

Only the SIMPOS authorized in the JPBO may be carried out during the ammonia bunkering and all involved parties must comply with the SIMOPS conditions specified in the JPBO.

Regulatory framework for SIMOPS in Rotterdam:

Article 8.3 Fulfilling minimum requirements for a bunker permit

3. The permit application should include the information set out in an application form as adopted by the harbour master.
4. The municipal executive can determine that, for certain fuels or energy sources, additional details must be provided during the permit application. This additional information relates to the regulations and restrictions referred to in the third subclause and could relate to an audit that the municipal executive may conduct for bunkering or debunkering activities carried out by the company.
5. Conditions and restrictions may be attached to the permit, including:
   a. the location where bunkering or debunkering may take place and the safety distances that must be taken into consideration during bunkering or debunkering;
   b. operational safety and the procedures governing the performance of bunkering or debunkering, as well as whether or not to permit other activities to take place simultaneously with bunkering or debunkering;
   c. nautical safety;
   d. external safety;
   e. making operational reports related to bunkering or debunkering, and;
   f. the subjects referred to in article 8.2(2)

Official Designation of Supplementary Provisions Concerning Specific Fuels, Additives and Energy Sources – Rotterdam 2023"
Article 4 – Simultaneous Activities During Bunkering and Debunkering (Article 8.1, Paragraph 5, Port Bye-Laws Rotterdam 2020)

1. The following fuels or energy sources may be bunkered or debunkered simultaneously with other activities:

a. Residual fuels and distillates (fuel oil and diesel);
b. Biodiesel;
c. Energy supply from a mobile production unit;
d. Shore power (grid connection); or
e. Heat supply from a mobile production unit.

2. The following fuels or energy sources may only be bunkered or debunkered simultaneously with other activities if this is done in accordance with the safety procedure set out in the Bunkering Management Plan of the receiving vessel, which has been incorporated into the specific bunkering action plan:

a. LNG or liquefied bio-natural gas (BLG);
b. LPG or Bio-LPG;
c. Methanol or bio-methanol;
d. Ethanol or bio-ethanol;
e. Liquid hydrogen;
f. Compressed hydrogen;
g. Hydrogen carriers;
h. Ammonia; or
i. Fuels or energy sources in packaging.

Pilot; PRL 6

No simultaneous operations were planned or prepared in the JPBO for the pilot, since this was the first operation of its kind in Rotterdam.

However, during the ammonia transfer, a surveyor reported for quantity/quality control. The visit was not included in the preparatory work as a SIMOPS and was unexpected by the Person in Charge (PIC). Although quality and quantity control by a surveyor is a common activity on board of vessels, the activity can interfere with the bunker handling since an additional person will be present in the safety zone. A task risk assessment should be performed to assess te activity to decide if the activity is acceptable during the bunkering from a safety perspective.

This risk assessment was executed, and the work of the surveyor could be done under the supervision of the Person in Charge (PIC).

Pilot recommendation

4.13a Recommendation
Address all expected SIMOPS in the J(B)PO. Make clear what the responsibilities and conditions and restriction are for simultaneous operations.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment; PRL 7

For the intermediate period, SIMOPS should preferably be avoided. If SIMOPS cannot be avoided, a project-based approach must be applied to ensure the required high level of safety for simultaneous operations.

Situations where SIMOPS should be avoided, or a SIMOPS assessment is required:

- A BMP of one of the involved vessels is incomplete regarding SIMOPS.
- The terminal is not prepared and not aware of the risks associated with ammonia bunkering.
- The compatibility assessment or JPBO does not address SIMOPS or fails to include the role of the terminal.

If the SIMOPS risk assessment is performed, appropriate risk mitigation measures should be incorporated in the JPBO. During the pre-operation meeting all involved parties, including the terminal, must review, underline and agree on the required measures. The agreed measures should be recorded in ammonia bunker checklist A of the IAPH.

The terminal must manage simultaneous operations using a project base approach to achieve an acceptable level of SIMOPS safety. For each specific call the terminal will be involved in the SIMOPS preparation by the vessels and the SIMOPS risk mitigation measures should be implemented by the terminal organization. The IAPH terminal Readiness methodology can provide an insight into preparing a terminal for ammonia bunkering in PRL 7.

Terminal preparation activities:

- SIMOPS preparation by a terminal safety team.

- Inform, instruct and train relevant terminal personnel on the subject.
- Develop and execute a communication plan for the call.
- Prepare the terminal incident response organization.
- Develop a terminal SIMOPS safety plan for the call.
- Designate terminal SIMOPS supervisors.
- Ensure the terminal and involved personnel can meet de required SIMOPS risk mitigation described in the JPBO of the vessel.
- Join the pre-operation meeting.
- Make an agreement on SIMOPS with the vessel's persons in charge of the vessel.
- Inform, instruct and train relevant terminal personnel on the subject.
- Train and instruct crane operators on the "do and don't' s during a bunker operation.
- Complete the I*APH Ammonia bunker* checklist A together with the personnel in charge of the vessels.
- Perform repetitive SIMOPS checks conform the ammonia bunker checklist.
- Additional measures as required.
-

Deployment - PRL 8 and 9

In future operational phases, SIMOPS during ammonia bunkering can be allowed when the following conditions are met:

- The terminal is ammonia ready according IAPH terminal readiness and prepared for SIMOPS
- The ammonia fueled vessel prepared a bunker management plan that addresses SIMOPS
- Use of a licensed dedicated ammonia bunker vessels with a bunker management plan that address SIMOPS.
- Comprehensive compatibility assessments are done, integrating all relevant information into a JPBO that includes SIMOPS risk mitigation measures.
- The IAPH ammonia bunker checklist B is used, including the Terminal Information Sheet
- All involved parties meet the required SIMOPS risk mitigation measures.
- Proper supervision on SIMOPS both on the ammonia fueled vessel and the terminal ammonia bunkering with simultaneous operations is required.

Validation Sheet

VS F010 Operational Safety; supervision-enforcement

General

The execution of a bunker operation is managed on a tactical/operational level by the officers of the vessel designated as Persons in Charge (PIC). They can be supported by an external supervisor of a service provider. On the terminal a designated terminal operator representative will manage the safety during bunkering.

To support the tactical management of the operation, IAPH tools are developed which focus on the interface and operations between the ammonia bunker vessel, ammonia fueled vessel and terminal such as the IAPH ammonia STS bunker checklist.

For most of the topics of the safety framework, on top of the safety management by the involved parties, competent authorities are checking regularly on the compliancy with regulations and local safety procedures.

Subject	Responsible Competent authority or management services
Vessel safety (construction)	Flag state, Class on behalf of the Flag state For foreign vessels in the Netherlands: Port state
Vessel traffic:	Coast Guard, Port State, Pilotage, Harbour Coordination Center, Vessel traffic Management (VTM), Vessel traffic Services (VTS), POR Patrol Vessels. Sea Port Police etc.
Mooring	POR Patrol Vessels
Vessel Operations	POR Enforcement officers, Port State, Dutch Shipping Inspectorate
Requirements and procedures for safe bunkering	POR enforcement officers
POR Reporting bunker operation	POR enforcement officers

The POR enforcement officers will visit the terminal and vessels to conduct reality checks and monitor compliance with rules and mandatory procedures. In case of safety breaches an enforcement officer can intervene, stop operations or make official reports.

Pilot; PRL 6

During the pilot, two Rotterdam enforcement officers (with additional expertise of alternative fuel specialists) were on board for monitoring and reporting compliancy with the safety regulations and requirements.

A POR Patrol Vessel was standby for enforcing the restriction zone for other vessels and supervision on mooring.

Deployment; PRL 7

For the intermediate period, when no long-term licenses are granted yet, project-based approach needs to be used to achieve the same required high level of safety. In a short-term license, competent authority will define requirements to assure the safety of the ammonia bunkering. The port authority will monitor the preparation of the operations and

has to approve the JPBO. Port of Rotterdam Enforcement officers check and monitor the compliancy with the Port Bye Laws, short term license requirements and other safety regulations as well as the compliance with the approved JPBO and SIMOPS agreements.

Deployment; PRL 8 and 9

For the future bunkering with dedicated ammonia bunker vessels, the license will be granted by the competent authority after a successful fulfilled audit process of the bunker operator. See the IAPH audit scheme for Clean Marine Fuels bunker operators and the Validation Sheet B: Licensing.

POR competent authority will also perform "Reality Checks" on board of the bunker vessel to assure the activities remain to be performed according to the procedures of the audited bunker operator.

And less frequent than in PRL 7, POR Enforcement officers check and monitor the compliancy with the Port Bye Laws, license requirements and other safety regulations as well as the compliance with the developed JPBO and SIMOPS agreements.

Validation Sheet

VS F 011 Port resilience and Emergency Response

General

One of the important aspects in Governance is the **Incident Response Preparedness** and **security** with a focus on ISPS for this operation. This VS consists of two parts: Incident Response Preparedness and Security.

1. Incident Response Preparedness

For Incident Response Preparedness in the port of Rotterdam the following six stakeholders are of key importance:

1. Vessels and their crews
2. Terminal
3. Port's Emergency and Incident response organization (ERO)
4. Environmental protection Agency – Rotterdam area
   Regional environmental agency for the province of South Holland and thirteen municipalities in the Rijnmond region, including the port area of Rotterdam.
5. Rotterdam-Rijnmond Safety Region
   Public body responsible for regional coordination in disaster response, crisis management, and public order.
6. Joint Fire Brigade Rotterdam
   The Joint Fire Brigade Rotterdam (GB) is a unique public-private fire service organization responsible for fire safety and incident response in the Rotterdam port and industrial area.

Incident response policy is developed in layers to support coordination and preparedness between these parties.

Pilot - PRL 6

The Governance team established the incident response preparedness consisting of representation from 2-6 and with input from the vessels (1).

Several meetings were organized, along with two site visits – giving the opportunity from all parties involved - to APMT where the pilot was to take place.
Based on these, safety measures for APMT were agreed upon, and an incident response plan for the pilot was developed by the designated parties.

For incident response preparedness the information from the dispersion study and QRA external safety for bunkering was used.

Important input for the safety zones was the information from the following two studies:

- a quantitative risk assessment based on multiple ammonia bunker scenarios to develop an "Ammonia Bunker map" to assure sufficient safety distance to vulnerable areas or populated aeras. (DNV)

- a gas dispersion study for the pilot bunker scenario (DNV) to set control zones for the ammonia bunker pilot and future bunker scenarios.

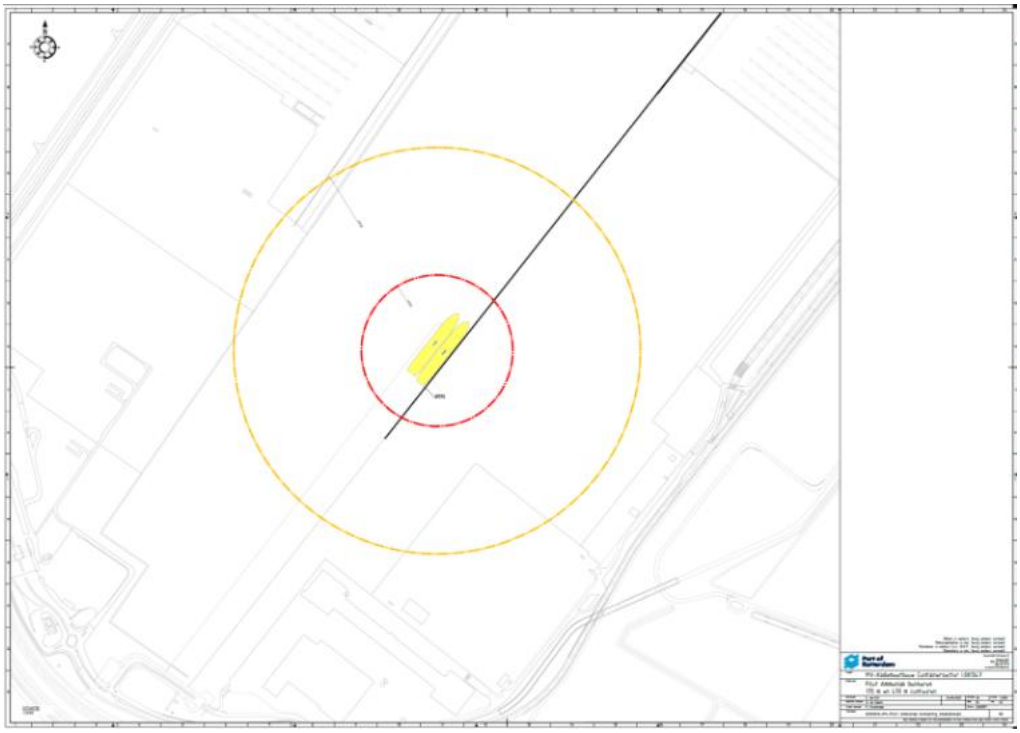
Based on these studies, two scenarios were identified as critical for this pilot operation:

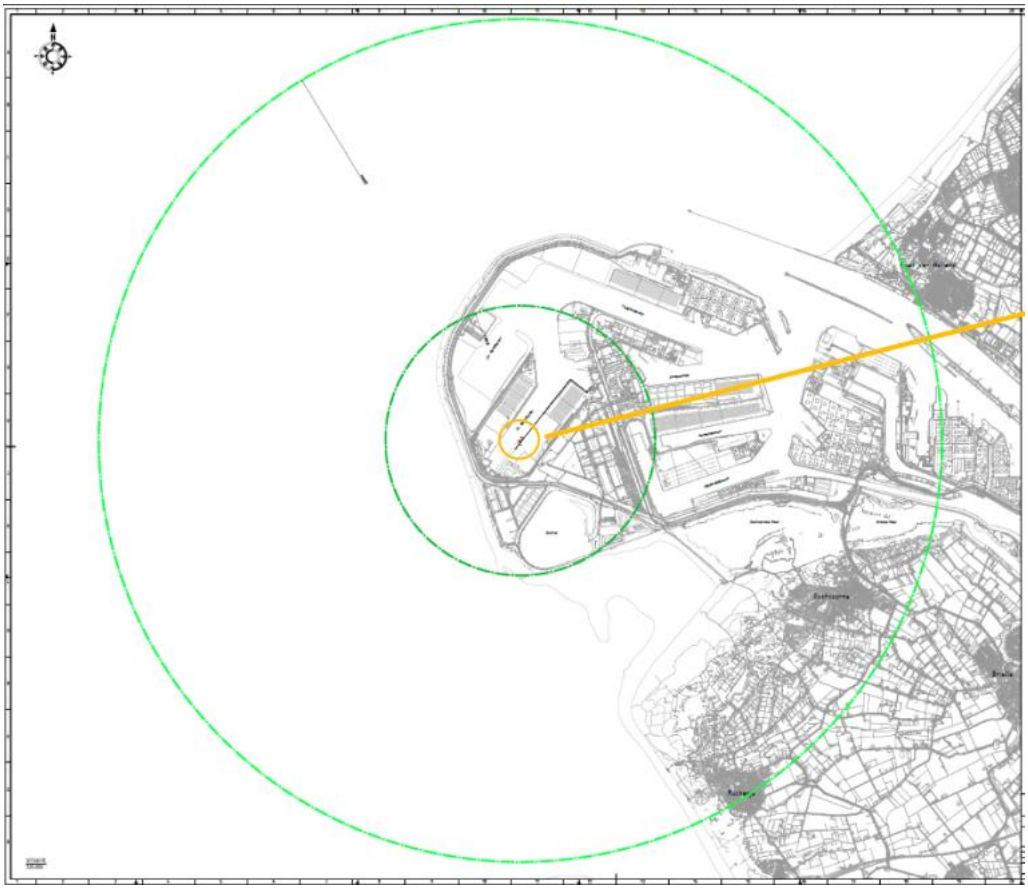
1. Failure of the bunkering hose, resulting in immediate release of its contents.
2. Continuous leakage, caused by a small hole leading to constant escape.

In both cases, the Emergency Shutdown (ESD) at the coupling point will be activated. This means that, at most, the entire content of the hose may be released—either instantly or gradually.

Based on these scenarios, safety zones have been established. The most unfavorable conditions were taken into account, and the safety circles were determined accordingly. Naturally, the actual circles on the day of operation also depend on wind direction and wind speed at that time. Four distinct zones were identified, which are listed below and shown in the picture's underneath:

- **Within the red circle (1101 ppm/1h, LBW-1h) – the Restriction Zone:**
  Only authorized personnel with safety instructions and protective equipment are allowed.
- **Between the red and orange circle (220 ppm/0.5h, AEL 2-30 min) – the Safety Zone:**
  During the transfer, presence should be kept to a minimum. Companies and any individuals present have been warned and know what actions to take.
- **Between the orange and dark green circle (30 ppm/1h, VRW 60 min) – the Information Zone:**
  SOMCOM and stakeholders (including companies) in the area have been proactively informed. Public spaces are subject to reactive communication based on a protocol.
- **Between the dark and light green circle (5 ppm – Odor Threshold) – Odor Zone:**
  Residential areas were informed about the pilot.





The pilot was scheduled between 18:00 PM – 07:00 AM with the aim to minimize the number of persons in the direct vicinity was present. The stakeholders in the direct vicinity were informed, identified by using Strategic Stakeholder Management

The Incident Response plan consisted of:

- A notification and alarm procedure
- Response and operational perspective for the emergency responders
  Content:
    - Vessel emergency response and contingency plan (see vessel input)
    - Response and operational perspective PoR DHMR
    - Response and operational perspective Fire Brigade Rotterdam
    - Response and operational perspective Joint Fire Brigade Rotterdam
- Communication approach when an incident takes place
  In the event of an ammonia incident requiring a multidisciplinary response, communication is the responsibility of the Rotterdam-Rijnmond Safety Region. They will coordinate the message, if necessary, with other parties such as DCMR and DHMR. Three communication messages were prepared:
    - One for the Restriction & Safety zone
    - One for the Information Zone
    - One for the Odor zone for the

Terminal

The pilot was conducted at APM Terminals. The pilot was performed alongside a part of the terminal under construction. No terminal activities were (yet) performed on this part of the terminal. This part of the terminal was still used as a layby berth.

This terminal is secured and ISPS compliant.

APMT has an emergency response plan that includes incident procedures for methanol and LNG bunkering.

The Terminal was assessed for preparedness conform the IAPH Terminal Readiness tool. However, there was no emergency procedure for ammonia available, neither in general nor specifically for the pilot. Therefore, specific preparation was done for the safe execution of the pilot:

- Relevant safety personnel of the terminal was informed
- Terminal was involved in the development of the Pilot Emergency Response plan
- No activities in the vicinity
- Accessible only to pilot-related personnel, and pre-registered with APMT security.
- Two access routes for the fire brigade were arranged to ensure accessibility in all wind conditions.

Pilot recommendations

3.3 Recommendation
Establish two exit/evacuation routes or ways of escape on board of the vessels.
Include the information in the JPO and make sure everybody is aware of the means for evacuation.

3.4 Recommendation
Make sure there are always two means of entrance and exit for the emergency response services and two ways of escape for the evacuation of personnel on/via the shore.

3.5 Recommendation
Since all efforts in preparing the barriers for the right side of the Bow Tie is done in three phases, first response by the vessels, second response by the terminal and third response by the shore incident response organization, exchange of each other's capabilities and equipment is essential.

4.12a Recommendation
Get knowledge from the Ammonia industry on best practice emergency response in case of a liquid ammonia leakage on board of vessels.
Supply dedicated ammonia bunker vessels with proper and suitable equipment for repression of liquid ammonia releases.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment; PRL 7, 8 and 9

For the Project- and system-based approach it is important that Incident Response preparedness is developed in such a way that, when a bunkering is scheduled, everyone is aware of their responsibilities and is competent in that role. The equipment needs to be in place, taking along the information from the Incident response plan from the pilot.

For future bunkering, the bunker incident scenarios and bunker incident response scenarios will be incorporated in the existing system for competence building, training and equipment of the emergency response organizations. The pilot was an opportunity to test the communication lines in case of an incident.

Vessel preparation

The first response in case of an incident during transfer of ammonia will be performed by the crew of the vessel. Based on the vessel's emergency response plans and contingency plans, the crew is equipped and trained in first response.

Equipment and contingency plans from the two vessels were the following

Contingency procedures of the vessels, how the vessel crew can react on spill or emissions.

Basically, all crew aware of their duty in case of cargo spill and crew will be educated to react on spill or emissions as per STS Contingency plan before arrival Rotterdam. A liquid gas leak or major spill on gas ships (STS contingency plan) was provided. A scenario at sea and at a terminal was included.

Fire fight equipment / capacity on board of both vessels. Equipment to be used to reduce the effect of an emission.

In case of deck fire, sea water system to extinguish and a dry chemical powder system.: The effect of an emission can be reduced by the sea water system.

Sea water system
-. 2 sets of fire/bilge pump in E/R (180/120 m3 x 30/100MTH)
-. 1 set of emergency fire pump (72m3 x 80MTH)
-. 1 set of Water spray system (490m3 x 60MTH)
Dry chemical powder system
-. 2 sets of DCP tanks (1,311.8kg / each)
Fireman's outfit
-. 5 sets of fireman's outfits with SCBA (6ltr x 314 Bar, 1,884ltr / each)
-. 2 spare cylinders for SCBA per each fireman's outfit.

Monitoring or gas alarm equipment (ammonia detection) installed on board of the vessels and portable ammonia measuring equipment available.

Fixed gas detection system for cargo and deck area
Brand: Consilium Marine AB
Type: Salwico SW2020
Fixed gas detection system for accommodation / Engine room area
Brand: Consilium Marine AB
Type: Salwico GD
Portable ammonia detector
Brand: Riken Keiki
Type: Eagle111-01/ SC-01
Total 3 sets

Crew on deck monitoring equipment

Portable ammonia detector on deck watch.

Spare personal detection devices on board for ammonia that can be used by Port authority supervisors.

1 set of portable gas detector and SCBA can be provided

OCEANIC MOON

Contingency procedures of the vessels, how the vessel crew can react on spill or emissions.

Gas Leak response procedures and plan

Fire fight equipment / capacity on board of both vessels. Equipment to be used to reduce the effect of an emission.

Deck Spray system information and plan provided.

Fixed Dry Powder system provided.

Monitoring or gas alarm equipment (ammonia detection) installed on board of the vessels and portable ammonia measuring equipment available.

Fixed Gas Detection System Omicron 2.1 and Portable Gas Detectors MSA Altair available with certificates. Information provided.

Crew on deck monitoring equipment

Portable Gas Detectors MSA Altair information attached (Altair 5X - 2pcs, 4X - 3 pcs, 2X - 4pcs) All certificates valid and in good working condition.

Spare personal detection devices on board for ammonia that can be used by Port authority supervisors.

MSA Altair 2X NH3 3pcs can be used by supervisors.

Superintendents were provided with their own PPE.

Vessel crew PPE

On board PPE sufficient for crewmembers as per SOLAS requirements.

Additional requirements for PoR representatives

PoR representatives and PoR superintendents should wear at all time PPE and on board of an LPG vessel it is not allowed to use any mobile & electronic devices.

During Key meetings representatives can be present but should not disturb Ch/Officers during meeting. All related question can be done only after completion of key meetings.

2. Security

In the Port of Rotterdam and 11 surrounding municipalities, the harbour master, acting as the Port Security Officer (PSO) on behalf of the mayor(s), is the authority responsible for security throughout the entire port area. To minimize the likelihood of security incidents at companies (port facilities), security regulations apply in the Port of Rotterdam. These rules are established by the International Maritime Organization (IMO) in the International Ship & Port Facility (ISPS) Code.

Relevant to the Ammonia bunker pilot the ISPS Code - besides other types of vessels - applies to Cargo ships of 500 gross tonnage or more sailing on international sea routes and therefore at all terminals where these vessels moor.

Security Level in the Port of Rotterdam
The security level is part of the ISPS Code. For terminals, these security levels are determined by the national government. For seagoing vessels, the level is determined by the flag state or the port state.

Risk assessments and security plans
Under the ISPS Code, the ISPS Assessment Team (consisting of staff from the Police, Customs, and the Port of Rotterdam Authority) prepares risk assessments for terminals that receive ISPS-regulated vessels.
These terminals must prepare a security plan describing their security measures. The ISPS Assessment Team reviews the plans and advises the PSO. It is up to the PSO to formally establish the risk assessments and approve the security plans if they meet requirements.
Seagoing vessels must also formulate a risk assessment and a security plan. These are assessed by the vessel's flag state or, on behalf of the flag state, a recognised security organisation.

Legal framework
The ISPS Code specifies the areas in which security measures must be implemented. These requirements are incorporated into European Regulation 725/2004. In the Netherlands, the Port Security Act (Havenbeveiligingswet) and the Port Security Regulation (Havenbeveiligingsregeling) also apply, defining various authorities and training requirements.

The port facilities that receive ISPS-regulated seagoing vessels must meet security requirements and each ISPS-regulated vessel must also have a risk assessment and a security plan, just like each port at an overarching level. Together, this forms a comprehensive ISPS security system.

Under the responsibility of the PSO also falls the ISPS oversight. More information about port security can be found on the website of the Port of Rotterdam Authority.

Pilot; PRL 6

The bunkering took place at a terminal that was under construction as part of the terminal's expansion. The existing terminal was already ISPS-compliant; however, the expansion also required an update to the ISPS, including the associated security aspects specific to that new quay section. This update was submitted in time and approved.

Deployment; PRL 7, 8 and 9

The relevant terminal (port facilities) that receive ISPS-regulated seagoing vessels must meet security requirements and each ISPS-regulated vessel must also have a risk assessment and a security plan

Validation Sheet

VS G Safety Checklists

General

The execution of a bunker operation is managed on a tactical/operational level by the officers of the vessel designated as Persons in Charge (PIC). They can be supported by an external supervisor of a service provider. On the terminal a designated terminal operator representative will manage the safety during bunkering.

Safe ammonia bunkering depends on good communication between the bunker vessel, the receiving vessel and the terminal and compliance with all agreed safety procedures. Checklists help to ensure all the appropriate checks are formally agreed, carried out and recorded.

To support the tactical management of the operation, checklists are developed with focus on the interface and operations between the ammonia bunker vessel, ammonia fueled vessel and terminal such as the IAPH ammonia STS bunker checklist.

Available checklists:

For loading the bunker vessel with ammonia from a terminal.

- The "Ship /Shore Safety checklist" published in the ISGOTT 6, developed by ICS, OCIMF, IAPH (1)
- The "Inland tanker-shore safety checklist" published in the ISGINTT, developed by CCNR and OCIMF (2)

For loading the bunker vessel with ammonia from an ammonia tanker

- The "Ship to Ship Safety checklist" published in the Ship-to-Ship Transfer Guide 2013, developed by ICS, OCIMF, SIGTTO (3)
- The "Ship to Ship Safety checklist" published in the Ship-to-Ship Transfer Guide 2025, developed by ICS, OCIMF, SIGTTO (4)
- The "Seagoing-Inland tanker / Inland tanker Safety Checklist" published in the ISGINTT, developed by CCNR and OCIMF (5)

For ammonia bunkering in the port of Rotterdam:

- Bunker checklist, Refrigerated Toxic Gas series, A" published at the products portal of the IAPH, developed by the IAPH/CMF (6)

Pilot; PRL 6

During the pilot, two LPG tankers carrying ammonia were used to perform the ammonia bunker pilot. From a technological point of view, the transfer during the pilot can be regarded as a transfer of cargo between two vessels, and the approach for the pilot was accordingly. For the pilot the vessels used several checklists.

Since the "Ship to Ship Safety checklist" published in the Ship-to-Ship Transfer Guide 2013 (3), is prescribed in the ISM of the LPG tankers, as well in the SMS procedures of the service provider, the 2013 STS checklist was used. In this checklist it is prescribed to complete the ISGOTT Ship/Shore checklist (1). Both vessels and the STS Superintendent, JF Fendercare, completed the 2013 Ship to Ship checklist and the checklist of JF Fendercare in which all ISGOTT topics were incorporated.

On top of the 2013 STS checklists both vessels, with support of JF Fendercare, completed the draft OCIMF 2025 STS transfer checklist (4). At the date of the pilot, the second edition of the Ship-to-Ship Transfer Guide (September 2025) wasn't published yet. To use the latest available checklist, the draft of the checklist 2025 was also completed by the vessels. In this version of the checklist all relevant topics of the ISGOTT (1) are incorporated.
In addition to the STS transfer checklists, the IAPH ammonia bunker checklist (IAPH Bunker checklist, Refrigerated Toxic Gas series, A) was partly completed as a trial of this checklist.

Note: checklist for inland vessels, in this pilot no inland vessels were involved.

Deployment; PRL 7, 8 and 9

When ammonia fueled vessels will be bunkered, for the intermediate period with LPG tankers with additional equipment and procedures, and in level 8 with dedicated ammonia bunker vessels, the IAPH ammonia bunker checklist (Bunker checklist, Refrigerated Toxic Gas series, A) have to be completed by both vessels and the terminal.

Checklist requirements in the Rotterdam Port Bye Laws:

> Article 8.7 Checklist for bunkering and de-bunkering and transferring ancillary substances on board
>
> 1. The municipal executive may establish checklists for bunkering or de-bunkering or for transferring ancillary substances from or on board.
>
> 2. The municipal executive can designate fuels, energy sources and ancillary substances as well as categories of vessels in which a checklist applies to the bunkering or de-bunkering of these.
>
> 3. The parties involved must complete a bunkering or de-bunkering checklist and must comply with this checklist and keep it on board the vessels concerned for at least 24 hours after the end of bunkering or de-bunkering.

Validation Sheet

VS H Ammonia fueled vessel Call

General

This document Appendix 1 of the MAGPIE report focused on the safety policy for the STS bunkering in level 7, 8 and 9

However, the port of Rotterdam must also be prepared for increased calls of ammonia tankers and calls of ammonia fueled vessels in the future without bunkering.

Increase of the transport of ammonia by ammonia tankers

On a regular basis, vessels carrying ammonia as cargo, ammonia tankers, call at the port of Rotterdam and this is covered in the existing safety systems to address the risks associated with ammonia as a cargo.
However, the port needs to assess regular whether the existing safety systems and infrastructure are sufficient for the expected increase in ammonia volume.

According to the current prognosis the increase can be facilitated by the present safety systems (Pilotage, Tugs, VTS, etc.). However, for every anticipated change in traffic patterns, for instance due to the development of a new ammonia terminal, a nautical safety assessment has to be performed to assess the effect on the existing situation.
If necessary, nautical safety studies will be performed such as collision risk studies, vessel traffic and course studies. Based on the results, additional risk mitigation measures can be implemented such as restrictions for ammonia tankers or/and other vessels in the vicinity, or additional nautical services like VTS or additional tugs etc.
The required risk mitigation for ammonia tankers has to be incorporated in the Rotterdam Admission Policy.

The call of an ammonia fueled vessel:

Since all safety systems in the port focus on the cargo on board the vessels, gaps exist in the regulatory- and admission framework for vessels sailing on ammonia.

Of course, a SOLAS certified ammonia fueled vessel complies with the international safety standards and should be considered as safe as all other vessels.

However, SOLAS or other existing regulations doesn't require reporting on the type and quantity of the bunkers on board of a vessel. There is no spatial planning system in place for vessels with ammonia in the bunker tank, and incident responders have no information on the ammonia on board, etc.

For bunkering of ammonia, a new safety system is developed to assure all involve parties are informed and instructed. For an ammonia fueled vessel alongside a terminal without bunkering there is not (yet) a mandatory safety system implemented. However, there are instruments available for a terminal to prepare it selves for a call of an ammonia fueled vessel such as the IAPH Terminal Readiness Tool en IAPH ammonia fueled vessel call checklist for terminals.

Port preparation for a call of an ammonia fueled vessel

The International Association for Port and Harbours (IAPH) published a Port Readiness Tool for the call of an ammonia fueled vessel. The port of Rotterdam uses this tool and the IAPH terminal readiness tools to prepare for calls of ammonia fueled vessels.

PRL 1, 2 and 3

In the research phase, the port of Rotterdam gathered insight in gaps in regulations and admission policy for a call of an ammonia fueled vessel. POR will adapt the admission policy based on risk assessment. For the time being, ammonia fueled vessels will be allowed to moor at berths that are also suitable for ammonia bunkering, as designated on the ammonia bunker map.

For ammonia specific attention is required due to the perception of communities, so Strategic Stakeholder Management and communication should be in place.

A Bow Tie risk study is performed to provide insight in barriers introduced to avoid an emission or spill of ammonia during a call of an ammonia fueled vessel (without bunkering). The study includes a gas dispersion / effect study based on credible leak scenarios, such as a leak in the Engine Room with an emission via the ER ventilation, or an emission via the vent stack due to a too high pressure in the bunker tank.

Some identified gaps that may arise are:

- A lack of knowledge on the location of ammonia fueled vessels in the port.
- Vessels will be on a berth in an unprepared environment.
- Unpreparedness of local emergency responders
- A lack of proper communication has led to a negative perception of ammonia

PRL 4, 5 and 6

Development Phase (PRL-MFs 4-6): The goal of the development phase is to make strategic decisions about admission policy and spatial planning for ammonia fueled vessels, and to create a guiding framework based on assessments and run a pilot for a first call of an ammonia fueled vessel.

- This includes the following activities: An Incident Response Preparedness study. The results of this study have to be incorporated in the emergency response organization and incident response procedures.

- Together with other Dutch Seaports a study is started to ensure proper and aligned reporting of ammonia as bunkers on board of vessels.

- Adaptation of IT systems to facilitate the reporting and sharing of information regarding the bunkers on board and showing the location of ammonia fueled vessels.

- Incorporating specific topics for ammonia fueled vessels in the admission policy including a system with approved locations for ammonia fueled vessels.

- A communication process will be started to reach to other authorities and the public with information on future ammonia propelled vessels

PRL 7

When ammonia fueled vessels call the port in PRL 7, for every visit a task risk assessment will be performed to check if the planned berth is suitable. This includes the following items:

- It should be a location indicated on the ammonia bunker map as suitable
- A check whether the terminal is aware of the fuel used on board and if the terminal is properly prepared for the risks related to the call of an ammonia fueled vessel
- All relevant stakeholders, such as emergency responders, VTS, POR superintendents etc. will be informed.
- The terminal call checklist of the IAPH will be used for checking the status of the ammonia fuel installation at arrival.

PRL 8 and 9

In PRL 8 and 9, ammonia fueled vessels will visit Rotterdam regularly. The following should be in place:

- A safety framework to assure the POR, the terminal, emergency responders and other relevant stakeholders are informed of the location of ammonia fueled vessels in the port.
- The admission policy for ammonia fueled vessels will manage the locations were ammonia fueled vessels are allowed.
- The POR organization, Emergency response organization and terminals are prepared for the calls of ammonia fueled vessels
- The terminal call checklist of the IAPH will be used for checking the status of the ammonia fuel installation at arrival.

Terminal preparation for a call of a vessel:

A terminal should be prepared for an ammonia fueled vessel alongside the terminal. Although this is not mandatory according to the Port Bye Laws, it is a necessity due to the safety management of the terminal which also should incorporate risk mitigation for external risks.

Guidance for a terminal on how to prepare for a call of a vessel can be found on the website of the International Association for Port and Harbours. The IAPH developed a tool for the preparation of a terminal for the call, and bunkering, of a clean marine fueled vessel.

See the "IAPH Clean Marine Fuels Ready Terminal Tool" at the IAPH site

This IAPH Terminal Call Checklist is developed specifically for terminal or site operators to manage operations involving vessels carrying alternative clean marine fuels, which are often flammable and/or toxic liquids or gases, intended for use in propulsion or auxiliary engines, with or without bunkering operations while alongside.

The checklist aims to ensure that such a vessel's fuel system does not introduce additional risks for the terminal and its operations, and that the vessel can be safely accommodated.

[Text source: IAPH-CMF]

Validation Sheet

VS 1 Strategic Stakeholder Management, Communication

General

Ammonia will play an important role in the transition to a more sustainable energy system, including as a more sustainable fuel for shipping. A major point of attention of ammonia is that it is a toxic substance, whereas the risks of other energy carriers and fuels mostly stem from their flammable and/or explosive nature. Therefore, stakeholder management is of key importance.

Stakeholder management already starts at a very early stage in the PRL – level 1 initial steps. At every level of the PRL stakeholder management remains important because the support of stakeholders is needed at every level for a supported implementation of ammonia.

See the IAPH PRL tool: https://www.iaphworldports.org/products/.

PRL 6 - Pilot

Alongside safety, stakeholder participation is a top priority as it is crucial for the success of the pilot and specifically important for the first-ever in port transfer of ammonia.
Besides the parties involved in the pilot, many relevant stakeholders were informed or involved, to foster trust and collaboration. This includes other authorities, such as the city council, companies in the area and the public.

1. Importance of stakeholder management related to the pilot.

a. **Building Trust and Credibility - Reputation**
Stakeholders were informed transparently and consistently to build trust and comfort about the pilot. It is of importance for the Port of Rotterdam that we communicate transparent on developments on energy transition in the port. Therefore, communication has been done with a wide group of stakeholders. Our stakeholders are of importance for long-term relationships and collaboration.

b. Reduce Resistance and Conflict
It was of high importance to communicate the why and how we prepared the pilot. Governance and Safety were the two main components for this communication. This allowed us to identify concerns before they could escalate, to address issues proactively and avoid misunderstandings or opposition.

c. **Improve Decision-Making**
Stakeholders like the municipality of Rotterdam, VRR and DCMR were involved to give input on, for example, information sheets. They brought valuable insights, expertise, and perspectives for the preparation and communication.

d. **Ensure Alignment and Buy-In**
The transparent communication was also meant to align expectations and ensures that everyone would understand the purpose, benefits, and impact of the pilot. We are very much aware that stakeholder support is very important for the introduction of ammonia in the port of Rotterdam and stakeholder management therefore is a continuous action.

e. **Support Risk Management**
This has been done in two ways.
- The full preparation related to incident response, see validation sheet incident response.

- Manage expectations. The environment to communicate on what we will do and how we prepared the safety framework with the possibility to reach out for more detailed information.

2. Stakeholder management and Communication

Initial steps: informing about the intention

Several initial steps were taken to inform key stakeholders:

- General - March 2024
  First step was at a workshop with national and international stakeholders. Communication on the way the Port of Rotterdam was preparing for an ammonia bunkering pilot (Port Readiness approach) and gather feedback from the varied and expert audience.
- Municipality of Rotterdam - April 2024 with follow up in July
  The municipality was informed explaining the intention of conducting a technical bunker pilot.
- The safety region (VRR) and Environmental agency (DCMR) were contacted in Q3 2024, with follow up in the Q4, to inform them on the intention to conduct a pilot and gather their feedback.

Second phase: providing specific information on the pilot

In the second phase dedicated stakeholder communication/information teams (4) were initiated for stakeholder management and communication.

City team

This team was responsible for giving the communication with the city administration and the cabinet (policy level) of the Mayor and Aldermen of the municipality of Rotterdam.

A factsheet was developed to inform the administrative and political levels of the municipality. A first version of the factsheet was shared in September 2024, followed by a second version in February 2025, intended to inform the aldermen. Also, input was given for a specific aldermen's briefing letter.

Governance team

This team was responsible for preparing the incident response plan together with the Environmental agency (DCMR), Safety region (VRR) and Joint fire brigade Port of Rotterdam.

SOMCOM team

Strategic Stakeholder Management and Communication
This team initiated a communication plan to reach out to all stakeholders - that were relevant because of transparency in awareness - in the pilot area and communication to the public in the area and small villages in the vicinity. An "ammonia pilot information sheet" was developed and distributed to all relevant stakeholders.

The developed Strategic Stakeholders Management and communication plan included:

- **Mapping stakeholders:**
  - Who are they?
  - How are they impacted?
  - In which zone are which active that need to be informed?
  - Who to be contacted by who?
- **Tailored messages:**
  - Why do we do this?
  - How to inform the different stakeholders in each zone?
  - Which mode of communication is preferred?
- **Timing and frequency**:
  - When should we engage who and how often?
  - When informing explicitly on the details of the pilot?
- **Feedback loops**:
  - How do we listen and respond to concerns?

The information was shared via e-mail and phone calls.

The e-mail was specifically intended for companies and municipalities to be informed because of awareness and information and only informational based on distance.

When more information was requested (feedback loop) actions were taken, such as:

- Contacting the company and providing verbal explanation e.g. how the safety preparedness was supported with studies.
- Involvement in sessions with smaller municipalities to explain the pilot purpose and preparedness using the levels and actions from the Port Readiness level tool.

Vicinity team (location of the pilot)

The vicinity team was established to reach out to companies close to the location of the pilot (in the inner control zones).
The following categories were identified:

- The companies involved in the construction activities for the terminal expansion.
- Companies located in the inner control zones
- Other activities in the weekend of the pilot period in the vicinity

These companies were contacted to discuss, if relevant, how to be prepared for a possible spill or emission of ammonia that could affect their companies.

Pilot recommendations

Recommendation SOMCOM 1
There are different decisions with their criteria, to be taken prior to the pilot e.g. safety, liability, incident response and the support of the stakeholders. It is very important that there is clarity who is responsible for which decision, internally and externally, and how to bring that together. Only then an overall go/no go decision can be taken.

Recommendation SOMCOM 2
The well prepared SOMCOM preparation has been very supportive. All stakeholders were properly identified, the information sheet was also useful for environmental management and for stakeholders. Very important is the feedback loop. Stakeholder responses need to be registered and dealt with by the relevant persons.

Recommendation SOMCOM 3
Communication needs to be done as timely and transparently as possible even if there is no specific update. Make sure that also the overall information is shared within the specific team to make sure there is comfort that all aspects are being taken care of.

3.1 Recommendation
In the dynamics of shipping, last moment changes are unavoidable. Ensure that the pilot workgroup members, related stakeholders and decisionmakers are informed on the dynamics with the related challenges to achieve sufficient agility and resilience in the preparation of the pilot.

3.2 Recommendation
Communicate as timely and transparent as possible even if there is no specific update. Make sure that also overall information is shared within the specific WGs to make sure there is comfort that all aspects are being taken care off.

See the Validation Sheet 00 "Pilot lessons learned and recommendations"

Deployment; PRL 7, 8 and 9

The pilot has delivered valuable input to develop the project-based approach. When preparing for the project-based approach the stakeholder management and communication requires a different approach than during the pilot.

Actions that need to be done towards level 7 are:

- Stakeholders need to be kept informed about the developments on ammonia bunkering.
- Communication needs to be done as timely and transparently as possible, even if there is no specific update.
- Additional information will be developed/provided like a bunker map indicating where ammonia bunkering can be allowed under which requirements. Allowed does not refer to only external safety though also e.g. nautical safe and how to take the environment into account. For this development communication with relevant stakeholders is an absolute condition.

Stakeholder management remains important moving from PRL 6/7 to PRL 8/9

Attachments VS Strategic Stakeholder Management and communication

1. **Main message**
2. **Information sheet**

Attachment 1 Main Message

Main message, t*he Why (general)*
"From the port, we aim to contribute to the decarbonization of seagoing vessels and the sustainable use of the sea and ports. This aligns with the **IMO's 2023 greenhouse gas strategy**, which has strengthened ambitions for international shipping. The targets include a 20% reduction in emissions by 2030, a 70% reduction by 2040 (compared to 2008 levels), and the ultimate goal of achieving net-zero emissions by 2050.

Developments in the maritime energy transition are moving rapidly, and shipping companies are actively seeking sustainable solutions for powering their vessels. Each segment of the global fleet has its own "best" solution, which means the port must prepare for a **multi-fuel future**. One of these developments involves ammonia-powered vessels, which are expected to call at the Port of Rotterdam and will need to be refueled (bunkered). Naturally, this requires extensive precautionary measures to ensure that bunkering is safe, responsible, and emission-free. These preparations are well underway. A key step in this process is the **ammonia bunkering practical test (pilot)**, during which all prescribed safety measures will be validated.

A key focus area is the **safety framework** for operations in the port. Within this framework, we are examining how the port should prepare, but also how to ensure safe operations per vessel and proper preparedness of operators, terminals, regulators, and others. With the technical bunkering pilot, we aim to **validate this safety framework**."

Attachment 2: Information sheet

Port of Rotterdam

PRAKTIJKTOETS
SCHEEPSBRANDSTOF AMMONIAK

INFORMATIEBLAD

Praktijktoets met overslag scheepsbrandstof ammoniak in Rotterdamse haven midden april 2025

Midden april vindt in de haven een praktijktoets plaats met overslag van de scheepsbrandstof ammoniak. Hierbij wordt ammoniak van het ene schip in het andere overgepompt (overslag). De haven bereidt zich hiermee voor op schepen die in de toekomst op ammoniak gaan varen en deze brandstof in de Rotterdamse haven willen tanken. Het Havenbedrijf Rotterdam vindt het belangrijk om betrokkenen te informeren over ontwikkelingen in de haven. U vindt daarom meer informatie over de praktijktoets in dit informatieblad.

De praktijktoets vindt plaats bij een nog niet in gebruik genomen kade van de APM-terminal in de Prinses Amaliahaven, zoals te zien op onderstaande kaart. Deze relatief afgelegen locatie is gekozen om de toets zo veilig mogelijk te laten plaatsvinden en mogelijke (geur)hinder te beperken. De bedoeling is om de toets halverwege april 2025 te laten plaatsvinden. Het precieze moment is afhankelijk van de gelijktijdige beschikbaarheid van de schepen. Het tijdstip van de toets, na 18.00 uur, wordt zo gekozen dat er zo min mogelijk bedrijvigheid en scheepvaartverkeer plaatsvindt.

Alles is erop gericht dat tijdens overslag van de praktijktoets geen ammoniak vrijkomt. Ammoniak heeft een sterke en typerende geur. Bij hoge concentraties en langdurige blootstelling kan de stof schadelijk zijn voor mens, milieu en natuur. Overslag tussen twee schepen of tussen een schip en een terminal is een gangbare activiteit in de haven voor veel verschillende stoffen, waaronder ammoniak. Hiervoor zijn medewerkers opgeleid en getraind en zijn specifieke installaties aan boord aanwezig.

Voor het uitzonderlijke geval dat ammoniak toch vrijkomt, zijn er specifieke voorbereidingen getroffen, waaronder het informeren van bedrijven in de directe omgeving van de toets en de aanwezigheid van de Veiligheidsregio Rotterdam-Rijnmond (VRR) en de Gezamenlijke Brandweer. Deze en andere maatregelen in de nabije omgeving zijn genomen op basis van recent onderzoek, waarbij in kaart is gebracht welke hoeveelheden ammoniak maximaal kunnen vrijkomen bij deze praktijktoets en tot welke afstand deze zich kunnen verspreiden.

Voorbereiding voor veilig werken met ammoniak in de haven

Ammoniak zal een belangrijke rol spelen in de transitie naar een duurzamere energievoorziening en scheepvaart. Een belangrijk nadeel van ammoniak is dat het een giftige stof is, waar de risico's van andere energiedragers en brandstoffen voortkomen uit hun brandbare en/of explosieve karakter. Overheden en bedrijven investeren daarom nu in een gedegen voorbereiding voor het werken met ammoniak in de haven.

In betreffende wet- en regelgeving, procedures en richtlijnen zijn extra maatregelen opgenomen om te voorkomen dat, ook na technisch falen of een menselijke fout, grote hoeveelheden ammoniak kunnen vrijkomen. Zo is wet- en regelgeving voor nieuwe opslagtanks voor ammoniak onlangs geactualiseerd en aangescherpt. Deze wordt nu gebruikt voor vergunningverlening. Voor de bouw van schepen die ammoniak vervoeren bestaat specifieke internationale regelgeving. Internationale regelgeving voor schepen die op ammoniak als brandstof varen wordt nu ontwikkeld. Daarnaast heeft de Rijkshavenmeester veiligheidsbeleid voor de scheepvaart specifiek voor ammoniak vastgesteld.

Bij die extra maatregelen kan voor terminals bijvoorbeeld worden gedacht aan stalen tanks die extra beschermd zijn met een betonnen buitenwand. Aansluitingen voor het overpompen van ammoniak zijn uitgerust met techniek die lekkages direct en vroegtijdig detecteert en automatisch medewerkers alarmeert, activiteiten uitschakelt en aansluitingen afsluit. Dergelijke maatregelen zijn ook verplicht bij het tanken van schepen, en dus ook bij de proef. Schepen moeten daarnaast extra ruimte hebben tussen de buitenwand van het schip en de opslagtanks voor ammoniak. Hierdoor is bij een aanvaring de kans zeer klein dat ammoniak vrijkomt. Bedrijven investeren daarnaast in scholing van medewerkers die met ammoniak gaan werken en ook de hulpdiensten zoals de Veiligheidsregio en de Gezamenlijke Brandweer voor de haven en industrie in regio Rijnmond bereiden zich hierop voor.

Verloop en maatregelen praktijktoets ammoniak

Tijdens de praktijktoets wordt er in enkele uren circa 1000 m³ vloeibaar ammoniak van -33 graden Celsius overgepompt tussen twee tankschepen. Onderdeel van de toets zijn de voorbereiding en afwikkeling aan boord van de schepen. De verwachting is dat de schepen ongeveer twaalf uur naast elkaar liggen. Uiteraard wordt er tijdens de handeling in de omgeving gemonitord op emissies.

Het Havenbedrijf heeft gespecialiseerde organisaties onderzoek laten doen naar de mogelijke risico's van de praktijktoets. Voor het onwaarschijnlijke geval dat een incident zich voordoet, is een zogenoemde verspreidingsstudie uitgevoerd voor scenario's die zich kunnen voordoen; een defect aan de slang waarmee de ammoniak van het ene schip naar het andere gaat en een lekkage aan de slang. De maximale hoeveelheid ammoniak die bij een defect door een breuk vrij kan komen, is de inhoud van een circa 20 meter lange slang. Bij een niet-geconstateerd lek door een defect kan de vrijgekomen hoeveelheid oplopen tot 3 m³.

In een cirkel van enkele tientallen meters, waarin alleen deelnemers van de proef aanwezig zijn, zijn daarom duidelijke veiligheidsinstructies nodig en beschikken mensen over persoonlijke beschermingsmiddelen, waaronder gasmaskers. In een grotere cirkel die de Maasvlakte raakt, kunnen mensen bij langdurig verblijf mogelijk irritatie van de huid ervaren zonder blijvende effecten op de gezondheid. In een nog grotere cirkel van enkele kilometers kan ammoniak worden geroken zonder gevolgen voor de gezondheid. De veiligheidsafstanden voor ammoniak zijn in dit geval vergelijkbaar met die van vloeibaar aardgas (LNG).

Goed veiligheidsbeleid is het belangrijkste aandachtspunt in de voorbereiding op de praktijktoets. De Divisie Havenmeester (DHMR), onderdeel van Havenbedrijf Rotterdam N.V., maakt dit veiligheidsbeleid in mandaat van het college van burgemeesters en wethouders van Rotterdam. Dit doet het Havenbedrijf in afstemming met relevante partners in de Rotterdamse haven, waaronder bedrijven, de gemeente Rotterdam, de Veiligheidsregio Rotterdam (VRR), de Gezamenlijke Brandweer (GB) en DCMR. De haven bereidt zich met de praktijktoets voor op schepen die in de toekomst op ammoniak gaan varen en deze brandstof in de Rotterdamse haven willen tanken. Doordat nu procedures in de praktijk worden getoetst, kan in de haven straks veilig en verantwoord ammoniak getankt worden. Ook andere havens wereldwijd zijn geïnteresseerd in het uitvoeren van een praktijktoets voor ammoniak. Rotterdam is de eerste haven in Europa die de praktijktoets uitvoert. Het Havenbedrijf faciliteert en stimuleert de internationale scheepvaart bij het terugdringen van de CO_2-uitstoot. Belangrijk onderdeel daarvan is het mogelijk maken van het tanken van alle soorten nieuwe scheepsbrandstoffen in de Rotterdamse haven.

CONTACT
Heeft u vragen of wilt u in contact komen met de betrokken organisaties?

Veiligheidsregio Rotterdam Rijnmond (VR-R)
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ACHTERGRONDINFORMATIE **AMMONIAK IN DE ROTTERDAMSE HAVEN**

De Rotterdamse haven is in transitie

De energietransitie is belangrijk voor een leefbaar klimaat en brengt veel veranderingen met zich mee voor de Rotterdamse haven en industrie. 13% van de energie voor Europa wordt aangevoerd via de haven. Dat gaat nu nog voornamelijk om de doorvoer van olie(producten), kolen en gas. In de toekomst zijn dat steeds meer duurzame energie, grond- en brandstoffen, zoals groene waterstof en groene elektriciteit. Hierdoor kan de uitstoot van voor het klimaat schadelijke broeikasgassen worden teruggebracht, zowel in de haven zelf als bij gebruikers van de energie wereldwijd, waaronder zwaar transport.

Om de overgang naar groene energie te kunnen maken, moet de haven worden toegerust op veranderende stromen van stoffen door de haven, waaronder alle nieuwe scheepsbrandstoffen en waterstofdragers als ammoniak. Deze veranderingen vragen veel voorbereiding. Op dit moment worden bijvoorbeeld nieuwe buisleidingen aangelegd voor CO_2 en waterstof en bouwen bedrijven aan nieuwe opslagtanks en fabrieken. Ook rederijen van zeeschepen bereiden zich voor op de energietransitie. Zij willen nieuwe producten kunnen vervoeren en schepen laten varen op nieuwe brandstoffen, waardoor de internationale scheepvaart kan verduurzamen. De haven van Rotterdam speelt hierin een belangrijke rol; hier worden veel brandstoffen geproduceerd en getankt (gebunkerd).

Ammoniak maakt waterstofimport op grote schaal mogelijk

Ammoniak is op verschillende manieren belangrijk in de energietransitie. Naast scheepsbrandstof gaat de stof ook het transport van waterstof mogelijk maken. Dat is belangrijk nu energie uit zon en wind wereldwijd in waterstof gaat worden omgezet om vervolgens te worden gebruikt om fossiele grond- en brandstoffen te vervangen in zwaar transport en de industrie. Met groene waterstof kunnen ook sectoren die heel veel energie verbruiken worden verduurzaamd. Europa heeft in de toekomst meer groene waterstof nodig dan het zelf kan maken. De Rotterdamse haven gaat daarom veel waterstof importeren.

Op dit moment is het transport van waterstof nog volop in ontwikkeling, omdat de technische en economische uitdagingen groot zijn. Waterstof is als gas erg lastig te vervoeren over grote afstanden. Het moet onder grote druk worden gehouden en neemt veel ruimte in waardoor veel schepen nodig zijn. Waterstof in vloeibare vorm is alleen over grote afstanden per schip te transporteren als het heel koud kan worden gehouden (-252 graden Celsius). Op dit moment zijn schepen die vloeibare waterstof kunnen vervoeren nog niet volledig ontwikkeld en daardoor nog niet beschikbaar.

Ammoniak is de eerste drager waarmee waterstof naar Rotterdam komt

Door waterstof te verbinden aan een andere stof, een waterstofdrager, kan het al op korte termijn relatief eenvoudig en efficiënt getransporteerd worden. Ammoniak is zo'n drager, net als methanol en Liquid Organic Hydrogen Carrier (LOHC). Alle dragers hebben voor- en nadelen op het gebied van kosten, leveringszekerheid, veiligheid, gezondheid, milieu, ruimtelijke inpassing, broeikasgas- en stikstofemissies.

De Rotterdamse haven wil waterstof in alle vormen en in alle dragers kunnen op- en overslaan, waarbij we verwachten dat ammoniak de eerste drager is waarmee waterstof naar de Rotterdamse haven komt. Over de hele wereld kiezen bedrijven voor het vervoer van waterstof op dit moment voor ammoniak als waterstofdrager. Voor hen is het een voordeel dat er al decennia in de industrie en logistiek met de stof wordt gewerkt en dat het vervoer van waterstof met ammoniak nu al veilig, technisch en economisch haalbaar is. Op langere termijn zullen ook andere waterstofdragers gebruikt worden voor het vervoer van waterstof naar Rotterdam.

De haven bereidt zich voor op varen en bunkeren met ammoniak

Vervoeren, overslaan en tanken van nieuwe (brand)stoffen met schepen wordt in de haven voorbereid volgens een internationale vastgestelde methode (Port Readiness Level assessment tool), waarbij veel aandacht is voor het beperken van verschillende milieu en veiligheidsrisico's van brandstoffen die brandbaar, explosief en/of giftig kunnen zijn. Deze methode wordt in havens wereldwijd gebruikt en in Rotterdam voor alle nieuwe (brand)stoffen doorlopen. Aan de hand van verschillende stappen wordt gezorgd dat wet- en regelgeving, veiligheid, infrastructuur en het aanbod op orde zijn om schepen met nieuwe brandstoffen te kunnen ontvangen in de haven.

Eerder doorliep de haven de methode al volledig voor scheepsbrandstof LNG en grotendeels voor methanol. Nu bereidt de haven zich voor op schepen die varen op ammoniak. De eersten daarvan worden in 2026 of 2027 verwacht. Voor de voorbereiding daarvan is het nu nodig om een praktijktoets uit te voeren waarbij procedures in praktijk worden gebracht.