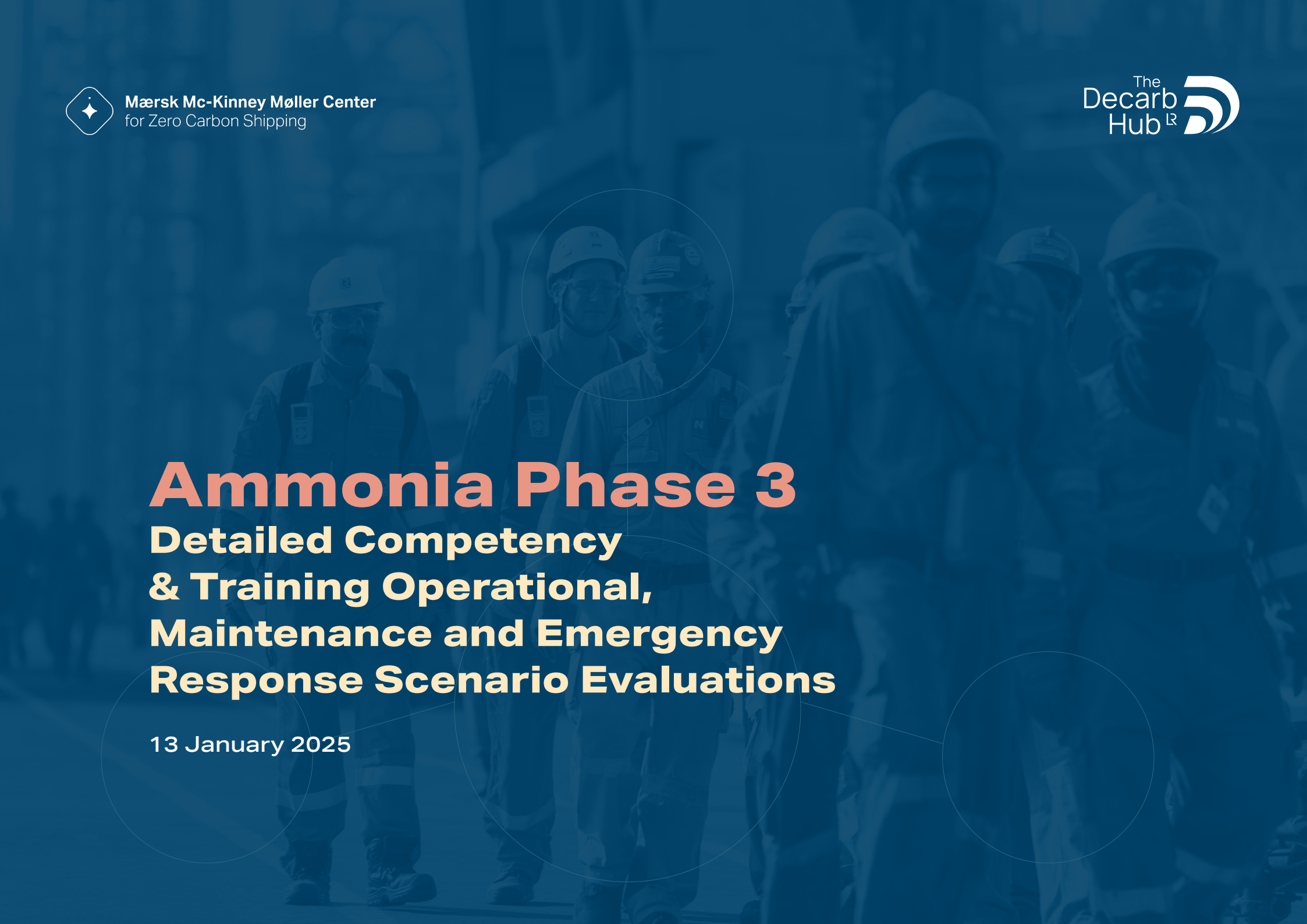

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

The Decarb Hub LR

Ammonia Phase 3

Detailed Competency & Training Operational, Maintenance and Emergency Response Scenario Evaluations

13 January 2025

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Executive summary

With the need to reduce carbon emissions, the maritime industry is looking to the use of alternative fuels to aid with their emissions reduction efforts. Ammonia as fuel has gained particular interest due to its zero-carbon potential, wide availability and previous carriage as a marine cargo. It is recognised, however, that to operate ships with ammonia, updates to seafarer training would be needed to adapt knowledge, understanding, proficiencies and skills to ensure ammonia does not compromise safety or create pollution.

A partnership was established between the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) and the Lloyd's Register Maritime Decarbonisation Hub (The Decarb Hub) to propose competencies and training criteria for the use of ammonia as fuel. This work, referred to as the Ammonia Phase 3 Competencies and Training project, was comprised of two major streams of work.

The first stream, published in July 2024, provided a Proposed Overall Framework for Ammonia as Fuel. The framework suggested minimum competency and training standards similar to those commonly documented in the International Maritime Organization's (IMO) International Convention on Standards of Training, Competency and Watchkeeping for Seafarers Code (STCW) and in fact, the existing mandatory STCW specifications of minimum standards of competence for basic and advanced training for ships subject to IGF Code was used as a model.

For the second stream of work, documented in this report, a more in-depth analysis of operations, maintenance and emergency response tasks was undertaken. This analysis provides detailed competency requirements and training standards for specific operations and maintenance tasks beyond those outlined in a typical STCW framework. As with the prior work in this project, it is assumed that seafarers would have previous experience and relevant credentials for working on ships using conventional fuels. It has also been assumed that these seafarers would be operating dual fuel engines with ammonia as one fuel but may not have previous experience with such engines or with the carriage of ammonia.

The challenge was to identify what additional competencies were needed for safely conducting operations, maintenance and emergency response tasks on ships using ammonia as fuel. Furthermore, it was important to suggest the training standards that would be associated with ammonia-related tasks on these vessels. The intention of this further set of evaluations is to provide the level of detail on operations and maintenance that the prudent ship operator may want to know prior to undertaking the use of ammonia as fuel.

To set the stage for the detailed work, the analysis was split into two distinct areas of focus; one evaluating the topics common to most ammonia fuel related tasks **(See Table 1)** and a subsequent one that reviewed selected operational, maintenance and emergency response tasks. **(see Table 2).**

Section	Table	Operational Scenario Commonalities
2	A	Ammonia as Fuel: Hazards, Characteristics and Hazard Awareness
3	B	Ammonia as Fuel: Overall Safety & Environmental / Risk Awareness
4	C	Ammonia as Fuel: Occupational Health & Safety
5	D	Ammonia as Fuel: Operational / Process Safety
6	E	Ammonia as Fuel: Regulations, Local requirements, Industry guidelines

Table 1. Operational Scenario Commonalities Topics

Section	Table	Selected Operational, Maintenance and Emergency Response Evaluations
7	F	Ammonia as Fuel: Hazards, Characteristics and Hazard Awareness
8	G	Ammonia as Fuel: Overall Safety & Environmental / Risk Awareness
9	H	Ammonia as Fuel: Occupational Health & Safety
10	I	Ammonia as Fuel: Operational / Process Safety
11	J	Ammonia as Fuel: Regulations, Local requirements, Industry guidelines
12	K	Ammonia as Fuel: Operational / Process Safety

Table 2. Selected Operational and Maintenance Evaluation Topics

During this project task, the focus of the analysis was to identify not only seafarer competencies and training standards but to differentiate which competencies and training applied to which seafarers based on their role. In addition, where it was recognised that seafarers may need to interface with or be assisted by those ashore, such interfaces and the potential training topics for those ashore were noted.

For this project, seafarers were broken into three distinct groups (management, operations, support) and shoreside was represented by four groups. The four shoreside groups were Company Corporate, Port Authority, Terminal Management and Shore Support Personnel. When a competency or training topic was considered to be applicable to a particular group, it was noted.

It is the intention of this document to propose a set of criteria for future competency requirements and training standards, beyond minimum standards commonly documented in STCW, to:

- Empower companies to train seafarers to be able to work safely, efficiently and in an environmentally responsible manner while using ammonia as a fuel on a ship with dual fuel engines.
- Suggest knowledge, understanding and proficiency requirements within the context of a seafarer's roles and responsibilities as they relate to ammonia fuel operations.
- Where possible, identify shoreside interfaces and their competency and training needs to promote effective collaboration.

This work can serve as an input to the development of future training and competency requirements for personnel on ships using gas and other low flashpoint fuels. In particular, the detailed information is aimed at the marine operations and training departments within companies choosing to operate ammonia fuelled vessels. It is also believed the information in this report could be informative to others with an interest in ammonia fuel such as regulators, flag States, port States, non-governmental agencies and training institutions. Some of the information here may also inform those addressing technical aspects of regulations.

While this report addresses the human factors considerations related to competencies and training, it should be noted that these topics are just one aspect of human factors that will need to be considered by industry when moving to the use of ammonia as a fuel. Others that deserve thought include:

- The ergonomic design of systems, equipment and interfaces.
- Supportive written procedures, processes and practices.
- Assessment of workload distribution given additional systems / hardware, interfaces and tasks.
- Any new roles and responsibilities for seafarers.
- The role of process safety and the management of process hazards in addition to those associated with traditional occupational health and safety.
- A formal method for managing change when moving from only using conventional fuel oil in engines to the addition of ammonia as a second fuel.

Many of these factors and their impacts are introduced in the document Human Factors Considerations: Ammonia Fuel End-of-Stage Report published by The Decarb Hub and MMMCZCS in 2023.

Disclaimer

The findings of this report are built on extensive cross-sector collaboration between organisations in the maritime industry and beyond. The project team consisted of the Lloyd's Register Maritime Decarbonisation Hub, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, A. P. Moller-Maersk, NYK Line, TotalEnergies, MAN Energy Solutions, BP, Cargill, CF Industries, Stolt Tankers, Anglo-Eastern Ship Management, Hapag-Lloyd, the Ammonia Safety & Training Institute (ASTI), Seaspan and V.Group.

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1. Introduction

Scope of Work: In December 2023, the Ammonia Phase 3 Competencies and Training project was initiated via a virtual meeting between project partners from the Mærsk McKinney Møller Center for Zero Carbon Shipping (MMMCZCS) and the Lloyd's Register Maritime Decarbonisation Hub (The Decarb Hub). In January 2024, the scope for the project was defined. Part of the scope of the project was the selection of a number of operational and maintenance activities for which detailed competencies and training standards would be identified and receive an indepth analysis.

This document provides the proposed competencies and associated training standards for a number of operational and maintenance scenarios that relate to both operational and maintenance tasks.

Background: During the scoping exercise conducted in January 2024, the detailed evaluation focus areas were structured into two parts: Operational Scenario Commonalities and Selective Operational, Maintenance and Emergency Response Evaluations. The tables below outline the various subsections under these two major categories. They also identify report sections and topics evaluated.

Section	Table	Operational Scenario Commonalities
2	A	**Ammonia as Fuel: Hazards, Characteristics and Hazard Awareness** ↗ Recognised major ammonia hazards and characteristics.
3	B	**Ammonia as Fuel: Overall Safety & Environmental / Risk Awareness** ↗ Establishment of various plans, risk assessment processes, safety / toxic / security-controlled zones, etc.
4	C	**Ammonia as Fuel: Occupational Health & Safety** ↗ Ammonia knowledge, first aid, personal protection, etc.
5	D	**Ammonia as Fuel: Operational / Process Safety** ↗ Process hazards and safe work practices such as risk assessment, job safety analyses (JSA), Permit to Work (PTW), Lock out – Tag out (LOTO); Enclosed Space Permit, Management of Changes (MOC), etc.
6	E	**Ammonia as Fuel: Regulations, Local requirements, Industry guidelines**

Table 1. Operational Scenario Commonalities Topics

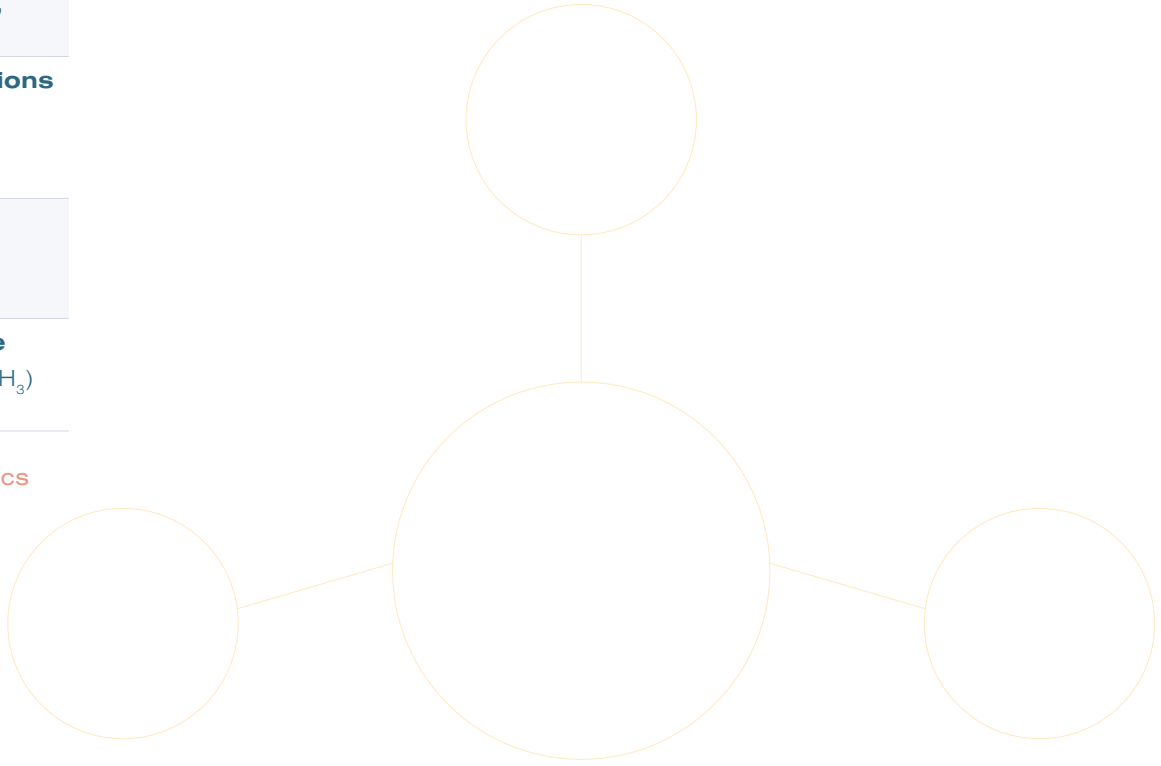
Section	Table	Selected Operational and Maintenance Evaluation Topics
7	F	**Ammonia Fuel Storage, Management and Transfers** ↗ Pressure / temperature control / monitoring; gas purging during fuel switchover from ammonia (NH_3) to conventional fuel oil (CFO). ↗ The scope starts at ammonia stored in an onboard tank and ends at the transfer to the dual fuel engine.
8	G	**Ammonia Gas Purging and Venting from Compartments** ↗ Routine purging / venting.
9	H	**Ammonia Leak Detection, Management, Isolation and Repair**
10	I	**Ammonia as Fuel: Simultaneous Operations (SIMOPs)** ↗ Introductory simultaneous operations information.
11	J	**Ammonia as Fuel: Maintenance** ↗ De-inventorying / de-energising. ↗ Requirements for supply / parts requests.
12	K	**Ammonia as Fuel: Emergency Response** ↗ Drills, emergency shutdown of ammonia (NH_3) supply, toxic releases, spills, firefighting.

Table 2. Selected Operational and Maintenance Evaluation Topics

Table Organisation. Each table itself is organised as follows:

Column 1 Project Number – for each entry	**Column 2** Topic	**Column 3** Competency and Training Standard	**Columns 4-8** Shipboard or Shoreside position related to the entry

Table 3. Various Columns within the Scenario Tables



Designation of shipboard seafarers related to competencies and training. Within the scope of the project, for each competency, based on the anticipated shipboard role and responsibilities of the seafarer, the applicability of a requirement was noted. In particular, a ● was used to designate if a particular set of competencies and training would apply. Seafarers on board the ship were assigned to one of the following categories:

Acronym	Shipboard Role	Description
SMT	**Management**	**Ship Senior Officers** – Master, Chief Engineer, Chief Officer and First Engineer.
SJO	**Operations**	**Ship Junor Officers** – 2nd Officer, 2nd Engineer, 3rd Officer, 3rd Engineer, Electrical Officer / ElectroTechnical Officer, etc.
SSR	**Support**	**Ratings** – Bosun / Boatswain, Able seaman, Ordinary seaman, Motorman, Oiler, etc. Other seafarers such as cooks, galley personnel and stewards would also fall under this category.

Table 4. Seafarer Categories

Designation of company corporate/shoreside entities related to competencies and training. For Company Corporate personnel, a column label “Corp” is provided within each scenario table and a ● is marked if a particular set of competencies and training would apply to them. Company corporate personnel can include shorebased personnel such as those in the operational, technical, safety, personnel and supply chain/procurement departments managing the ship. This category would also include the designated person ashore (DPA).

For Shore based personnel (with a column marked “Shore”), a code is provided when a particular set of competencies and training would apply to them. These were organised as follows:

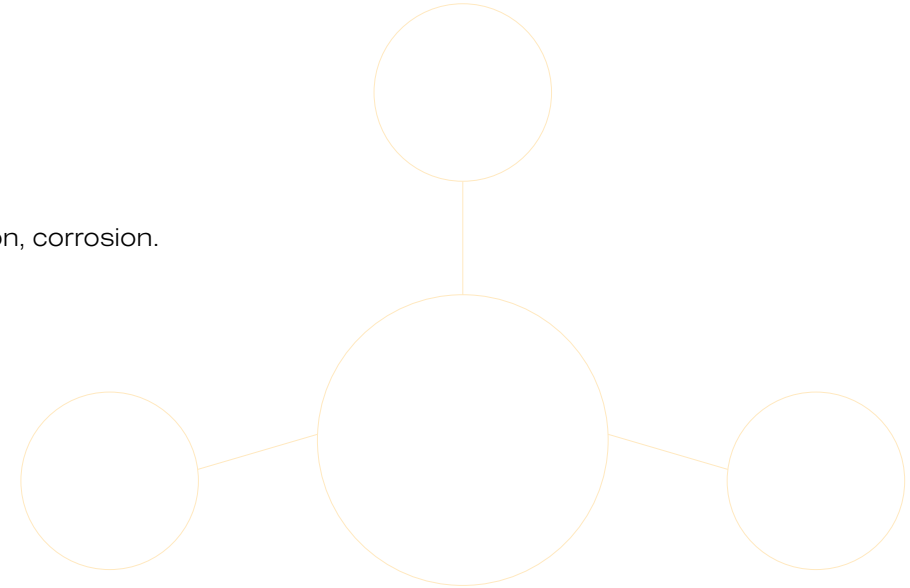
Acronym	Shipboard Role	Description
PA	**Port Authority**	Represents a government entity that governs port entries and operations.
TM	**Terminal Management**	Represents port or terminal managers, supervisors and other terminal personnel. This would also include any emergency responders such as local / shoreside fire teams.
SP	**Shore Support Personnel**	Represents bunker barges, waste reception barges and tugs and emergency response entities such as salvers.

Table 5. Shorebased Personnel Categories

2. Table A: Ammonia as fuel: Hazards, Characteristics and Hazard Awareness

This section provides the proposed competencies and associated training standards for fuel hazards, characteristics and hazards awareness as it relates to carrying ammonia as fuel on board ships. It provides suggestions for new or modified competencies and training above and beyond those that exist for conventional fuel oil. This section includes:

- General knowledge and awareness.
- Gas laws and thermodynamics.
- Reactivity.
- Density and phases.
- Release behaviour.
- Solidification / hydrate formation.
- Various hazards such as pressure, toxicity, flammability, explosivity, implosion, corrosion.
- Materials and metals compatibility.
- Health hazards.
- Weather or external environmental conditions.



No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A1	General knowledge	Detailed knowledge of physical and chemical properties of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Physical appearance and state. ↗ Smell. ↗ Toxicity. ↗ Flammability. ↗ Solubility. ↗ Explosivity. ↗ Reactivity. ↗ Corrosivity.	●	●		●	PA, TM, SP
A2	General awareness	Awareness and basic understanding of ammonia chemical and physical properties and characteristics to the level appropriate to shipboard role. **Training programme should encompass imparting knowledge on:** ↗ Physical appearance and state. ↗ Smell. ↗ Toxicity. ↗ Flammability. ↗ Solubility. ↗ Reactivity. ↗ Corrosivity.			●		SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A3	Gas laws and thermodynamics	Understanding of gas laws and physics related to changes of state and how they apply to ammonia operations. **Training programme should encompass imparting knowledge on:** ↗ Energy density. ↗ Latent heat of vaporisation. ↗ Autoignition temperature. ↗ Liquid density. ↗ Adiabatic Flame Temperature at 1 Bar. ↗ Molecular weight. ↗ Melting point. ↗ Boiling point. ↗ Dew point. ↗ Flash point. ↗ Explosive and flammable limits (UEL, UFL, LEL & LFL). ↗ Critical temperature. ↗ Critical pressure. ↗ Triple point. ↗ Decomposition temperature. ↗ Vapour pressure. ↗ Flammable range in dry air. ↗ Minimum ignition energy. ↗ Heat and energy transfer. ↗ Refrigeration and liquefaction of gases. ↗ Diffusion and missing gases. ↗ Behaviour of cold gas clouds.	●	●		●	TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A4	Reactivity	Understanding of the reactivity of ammonia with other substances. **Training programme should encompass imparting knowledge on:** ↗ Hygroscopicity – high affinity to water/moisture ↗ Exothermic reaction of ammonia with water to form a corrosive alkali Ammonium hydroxide ↗ The potential for ammonia to form explosive compounds with chlorine, iodine, bromine, calcium hypochlorite, mercury, gold, silver oxide, silver hypochlorite, bleaches and some halogens ↗ Incompatibilities with some metals; polymers such as plastics, elastomers; and sealants	●	●		●	PA, TM, SP
A5	Density	Knowledge of factors that influence the density of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Density of ammonia in different phases, and at different temperaturepressure conditions ↗ Density of ammonia gas – lighter than air at 0.699 kg/m^3 ↗ Effect of humidity in the air on density of ammonia vapours – can result in being heavier than air in high humidity conditions	●	●		●	PA, TM, SP
A6	Phases	Understanding of the phases and phase boundaries of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Ammonia phase diagram – phase boundaries, triple point and critical point. ↗ The phases in which ammonia can exist – gas, liquid and solid phases. ↗ The effect of temperatures and pressures on different phases of ammonia. ↗ Circumstances influencing phase changes and in particular from liquid to gas. ↗ The factors that can influence the phase boundaries, and the formation of hydrates. ↗ The processes for refrigeration or pressurisation of ammonia.	●	●		●	PA, TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A7	Release behaviour	Understanding of release behaviour of liquified ammonia in different storage conditions. **Training programme should encompass imparting knowledge on:** ↗ The liquidtogas expansion ratio of ammonia when inadvertently released or leaks off from its containment. ↗ Types of ammonia releases and factors relating to the type of release: liquid, aerosol (twophase), vapour. ↗ The release behaviour of refrigerated liquified ammonia, wherein the vapour release rate will principally depend on the liquid temperature, vapour pressure, evaporating surface dimensions, and ventilation. ↗ The release behaviour of compressed liquified ammonia, wherein the vapour release rate will result in instantaneous evaporation (i.e. flashing the vapour release rate is nearly equal to the leakage flow rate). However, the degree of vapour flash depends on the liquid temperature, pressure, release orifice characteristics, and ambient conditions.	●	●		●	TM, SP
A8	Solidification / hydrate formation	Understanding of the conditions leading to and implications of potential plugs/blockages in equipment or lines if pressure and temperature are not maintained within limits. **Training programme should encompass imparting understanding on:** ↗ Conditions leading to formation of plugs or blockages. ↗ The consequences of plugs or blockages. ↗ Steps to treat potential blockages or plugs such as methanol injection.	●	●		●	TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A9	Pressure hazards	Understanding the anticipated pressure hazards with ammonia storage and handling. **Training programme should encompass imparting understanding on:** ↗ Liquid to gas expansion of ammonia. ↗ Factors that can lead to overpressures. ↗ Formation of vacuum in the ammonia storage and handling equipment. ↗ Potential of vacuum formation in an enclosed space due to the absorption of ammonia by water/moisture.	●	●		●	PA, TM, SP
A10	Flammability and explosivity	Understanding of flammability and explosivity of ammonia. **Training programme should encompass imparting understanding on:** ↗ The flammable range of ammonia in air – lower explosive limit (LEL) and upper explosive limit (UEL). ↗ Autoignition temperature of ammonia vapours. ↗ Conditions that can promote the vapour concentration to attain the flammable range. ↗ Conditions that can trigger an explosion from accumulation of ammonia vapours. ↗ Potential impact of ignition sources. ↗ Impacts of the use of the ventilation system. ↗ The flammability range of ammonia in air and measures that need to be taken to prevent spaces from developing flammable mixtures. ↗ The potential of failure of ammonia tanks to cause boiling liquid expanding vapour explosion (BLEVE). ↗ The potential of ammonia tanks to explode when exposed to high heat, and measures to be adhered to prevent the occurrence. ↗ The potential of contact with strong oxidisers that can result in fire or explosions.	●	●		●	PA, TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A11	Implosion	Understanding the potential of implosion of ammonia storage tanks. **Training programme should encompass imparting understanding on:** ↗ The factors that can promote the development of vacuum in ammonia storage tanks including the presence of water/ moisture.	●	●		●	TM, SP
A12	Corrosion	Understanding the corrosion potential of ammonia and compounds of ammonia with an emphasis of the means to decrease the potential for hazards. **Training programme should encompass imparting knowledge on:** ↗ Factors that can contribute to corrosion including moisture content and the effect of water in ammonia systems in leading to corrosion. ↗ The effect of moisture/water on anhydrous ammonia in shifting the pH and forming ammonium hydroxide which is a corrosive alkali. ↗ Measures and best practices to eliminate or reduce the impacts of moisture/water in ammonia systems. ↗ Actions to eliminate/reduce the water content. ↗ Understanding of failure mechanisms and conditions that promote them in ammonia systems. This would include the risk of embrittlement from low temperatures and stress corrosion cracking in mild steel. ↗ Understanding of stress corrosion cracking mechanisms in ammonia systems for carbon steels or copper or its alloys. ↗ Criticality of replacement of components with original equipment maker (OEM) components to avoid incompatibilities.	●	●		●	TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A13	Material compatibility	Knowledge of material selection and application of materials for preventive control while preserving fuel quality. Knowledge of materials incompatible with ammonia and potential for hazards. This information should be provided to the level of detail appropriate to a seafarers' role. **Training programme should encompass imparting understanding on:** ↗ Compliance with design specifications, manufacturer's requirements, and Company operating / maintenance procedures. ↗ Material / metal incompatibilities within ammonia systems. ↗ Precautions with use of conventional rubber, some plastics, polymers such as elastomers; and sealants. ↗ Metals that are compatible with ammonia such as aluminium, steel and stainless steel. ↗ Metals that are incompatible and / or can be corroded such as galvanised metals, cast iron, copper, brass, zinc, nickel and their alloys. ↗ Potential for pure anhydrous ammonia to attack certain high tensile strength steels and to initiate stress corrosion cracking. Increased susceptibility with higher strength steels especially in areas of high residual or applied stresses. ↗ Strong acids, strong bases, strong oxidisers and hypo chlorites to be avoided. Impacts of these which can change the ammonia solution and lead to reactions. ↗ Criticality of replacement of components with OEM components to avoid incompatibilities.	●	●	●	●	TM, SP
A14	Health hazards	Understanding of the health hazards associated with ammonia. **Training programme should encompass imparting understanding on:** ↗ • Eye, skin, mucosa and respiratory system irritation/burns. ↗ • Asphyxiation/displacement of oxygen. ↗ • Toxicity. ↗ • Low temperature exposures. ↗ • High pressure effects.	●	●	●	●	PA, TM, SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
A15	Toxicity	Understanding of the toxicity of ammonia. **Training programme should encompass imparting understanding on:** ↗ The effects of accidental contact of ammonia liquid with skin, eyes and ingestion. ↗ The threshold limit value (TLV) for safe continuous working against time of exposure. ↗ The effects of exposure to ammonia at different concentration levels, and the corresponding responses to such exposure. ↗ Occupational health related information related to concentration, AEGL, time windows and first aid measures for exposure.	●	●		●	PA, TM, SP
A16	Weather or external environmental conditions	Knowledge of weather and environmental factors that could affect ammonia operations, including bunkering. **Training programme should encompass imparting understanding on:** ↗ Sea states and ship motions affecting sloshing and vapour generation based on tank design ↗ Weather conditions including temperature influencing operations. ↗ Atmospheric conditions affecting vapor dispersion in case of a leak. ↗ Atmospheric conditions like humidity affecting personnel especially those wearing PPE. ↗ Weather restrictions with regards to ammonia operations such as bunkering.	●	●		●	PA, TM, SP

3. Table B: Ammonia as Fuel: Overall Safety & Environmental / Risk Management

This section provides the proposed competencies and associated training standards for overall safety, environmental and risk management as it relates to carrying ammonia as fuel on board ships. It provides suggestions for new or modified competencies and training above and beyond those that exist for conventional fuel oil operations. This section includes:

- Safety / risk management.
- Safety systems.
- Controlled zones.
- Access to ship and zones.
- External influences on ammonia operations.
- Coordinating emergency response including reporting.
- Operations in port – stop work.
- Environmental impacts including overboard discharges.
- Waste offloads related to ammonia.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B1	Safety / risk management – processes and plans	Understand the need and process for identifying shipboard risks and contingencies related to ammonia as a fuel. Understanding prevention, mitigation, and emergency actions related to ammonia systems and equipment. Understand how to plan work carried out under a risk assessment to ensure ammonia risks are managed. **Training programme should encompass imparting knowledge on:** ↗ Potential ammonia hazards. ↗ Risk assessment and safe work practice methodologies. ↗ Management of change (MOC) requirements/processes. ↗ Safety management system requirements. ↗ Planning of operations.	●	●		●	
B2	Safety / risk management compliance	Ability to identify situations where risk assessment will be required to identify potential required safeguards as well as communicate and implement these. Ability to modify, as needed, any standardised /preexisting risk assessments for ammonia operations. Ability to conduct and monitor work carried out under a risk assessment to ensure risks are managed. This would include tasks related to operations, inspection and maintenance related to ammonia systems particularly those requiring work permits (e.g., JHA / JSA, confined/enclosed space, LOTO, etc.). Ability to recognise when situations or conditions change from those set in the risk assessment and next steps for addressing situation. **Training programme should encompass imparting knowledge on:** ↗ Potential ammonia hazards. ↗ Risk assessment and safe work practice methodologies ↗ MOC requirements / processes. ↗ Safety management system requirements. ↗ Leadership, supervision, planning and communications.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B3	Safety systems	Knowledge of shipboard safety systems including communications systems, emergency shutdowns, fire / gas detection alarms, general alarms and emergency response equipment. **Training programme should encompass imparting knowledge on:** ↗ Leadership, supervision, planning and communications. ↗ Communication devices, channels, protocols. ↗ Industry guidelines and protocols. ↗ Safety and emergency devices, equipment or protections.	●	●		●	TM.
B4	Safety management approach – planning operations	Ability to determine overall safety management approach to be used for joint operations with other organisations including ability to establish agreement on integration of the various safety rules to be followed across the various organisations. Ability to plan and create a joint / cooperative plan, taking into account, relevant regulations, port or ship requirements, different involved organisations capabilities and restrictions. The planning must also work across the involved and where necessary, combine, the various parties' safety management systems. **Training programme should encompass imparting knowledge on:** ↗ Potential ammonia hazards. ↗ Safety management system requirements for own organisation. ↗ Leadership, supervision, planning and communications.				●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B5	Safety management of coordinated operations	Ability to demonstrate leadership abilities related to safe and environmentally sound ammonia operations, maintenance and emergency response tasks. This includes the ability to effectively plan and conduct operations that involve other organisations. Ability to effectively work across and communicate with various organisations where organisational interfaces are needed. This would extend to being knowledgeable about the various phases of the planned/shared operations as well as operational and safety parameters. Ability to follow set procedures and checklists for operations, inspection and maintenance. This would include familiarity with checklists used during joint operations such as SIGTTO, OCIMF, SGMF, etc. Ability to oversee and monitor joint / coordinated operations. Ability to establish and maintain effective communications between various participants throughout coordinated operations. This would include agreement of established channels, means and protocols of communications with internal and external stakeholders including port, terminals, tugs, contractors, vendors. Ability to conduct monitoring throughout operations. Understanding when and how to report anomalies. This would extend to knowledge of ammonia PPE, communication channels, low temperature protection, gas monitoring, emergency related equipment / response. Ability to manage the sequencing of operations, simultaneous operations (SIMOPs) and MOC. **Training programme should encompass imparting knowledge on:** ↗ Leadership, planning and communications. ↗ Communication devices, channels, protocols. ↗ Regulations and industry guidelines and protocols. ↗ Safety and emergency devices or protections. ↗ Operations monitoring requirements including actions, parameters, processes. ↗ Reporting requirements including off normal situations.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B6	Communications to various parties emergencies	Ability to convey information related to shipboard emergencies such as dispersion characteristics, system capabilities/limitations to internal and external interested parties. This would include communications during preplanning or after venting. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties. ↗ Ammonia system, equipment, safety devices. ↗ Vapour cloud formation and dispersion. ↗ Leadership, leadership, supervision, planning and communications ↗ Purpose of hazardous zones for safety, security, and marine. ↗ Establishing and monitoring hazardous zones.	●			●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B7	Controlled zones – purpose and types	Understanding of different hazardous / safety zones established on board the ship and at the shipshore interface, and the specific requirements within each of these zones. These could include safety, toxic, security or marine zones. Knowledge of location of zones especially in the vicinity of ventilation, pressure relief outlets or vents masts. Understanding of the vapour cloud dispersion characteristics of ammonia and factors that can adversely affect the vapour dispersion. **Training programme should encompass imparting knowledge on:** ↗ Risk assessment processes including gas dispersion analysis for determining zones. ↗ Purpose of controlled / hazardous zones for safety, toxic, security, and marine. ↗ Role of the port / local authority or terminal management for establishing zones ashore. ↗ Establishing and monitoring controlled / hazardous zones based on operations like bunkering, activities such as cargo operations, or external situations or conditions. ↗ Requirements or restrictions within the zones. This could include the limitation of ignition sources. ↗ Factors such as atmospheric and weather conditions that can affect vapour cloud dispersion and impact where zones are placed. ↗ Regulatory requirements and/or industry guidelines.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B8	Controlled zones awareness	Familiarity with the purpose of safety, toxic, security and marine zones, when they are used nearby or ashore and what is needed to comply with rules for these. **Training programme should encompass imparting knowledge on:** ↗ Potential impact of zones established outside the ship and how they could impact shipboard operations. ↗ Compliance requirements for the ship.			●		
B9	Controlled zones communications	Ability to identify and communicate any anticipated or actual changes to the designated controlled / hazardous zones, and corresponding requirements within them. **Training programme should encompass imparting knowledge on:** ↗ Controlled zones, and the specific requirements within these zones. ↗ Categorisation of controlled zones and specific requirements to be followed within each category.	●	●	●		PA. TM. SP
B10	Access to ship and zones	Knowledge of safety and security measures for operations such as access to vessel or local area, including safety, toxic, security or marine zones. **Training programme should encompass imparting knowledge on:** ↗ Safety and security protocols. ↗ Vetting and clearance requirements for access.	●	●		●	PA, TM. SP.
B11	Safety management recordkeeping	Knowledge of plan, risks, requirements, procedures/processes and recordkeeping for ammonia fuel usage. Knowledge of plans, procedures and requirements for maintaining relevant records of system operations, inspection and maintenance. **Training programme should encompass imparting knowledge on:** ↗ Regulations and Company requirements.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B12	External influences on ammonia operations	Familiarity with marine aspects of operation including mooring, stability, securing of vessel, influences of weather, meteorological and local conditions. Local conditions to include tides, current, vessel traffic. **Training programme should encompass imparting knowledge on:** ↗ Marine conditions that can affect the carriage of ammonia onboard such as increasing vapour generation, formation of gas pockets, etc. ↗ Vapour generation, cloud formation, dispersion, and the impact of local atmospheric or weather conditions.	●	●		●	PA. TM. SP.
B13	Coordinating emergency response including reporting	Ability to coordinate shipboard ammonia related incident response for safety, security, environmental or other emergency events. This includes reporting and documenting incidents. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties and impacts. ↗ Regulations and requirements. ↗ Incident reporting to include understanding of various organisations to be informed (Including port authority, terminal, other vessels, flag, class, etc). ↗ Leadership and communications.	●			●	
B14	Operations in port – stop work	Ability to oversee and terminate, if necessary, any operations including SIMOPs, taking place during operations at berth. **Training programme should encompass imparting knowledge on:** ↗ Leadership, supervision, planning and communications. ↗ Communication protocols.	●	●			TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B15	Environmental impacts	Understanding the environmental impacts of shipboard ammonia releases – both as liquid and gas. Knowledge of the response to ammonia releases to prevent or minimise the impact on the environment. Understanding the potential for the creation of nitrogen oxide (NOx) from the use of ammonia fuel and steps to minimise it. Understanding the potential for the creation of nitrous oxide (N_2O) from the use of ammonia fuel. Understanding the potential for ammonia slip and particulate. Familiarity with ammonia system including ventilation, venting. Use of ARMS to reduce the potential for release or fugitive emissions. Proficiency in using engineered systems (such as ARMS, SCRs or EGRs) to reduce emissions. **Training programme should encompass imparting understanding on:** ↗ Potential health and climate impacts related to the use of ammonia as a fuel. ↗ Dispersion characteristics and factors influencing dispersion of ammonia vapours ↗ Impacts of ammonia fuel for creation of NOx, N_2O, ammonia slip and / or particulate matter. ↗ Influence of ammonia spills to sea and impacts on aquatic life such as longlasting effects. ↗ Relevant techniques / processes and engineered systems to reduce the impact of ammonia slip, N_2O, NOx or spills. ↗ Emergency response procedures including spill containment.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
B16	Overboard discharges	Awareness that ammonia is considered to be acutely and chronically hazardous to the aquatic environment and to marine life. Familiarity with measures to contain any spills with dykes or absorbents to prevent migration and entry overboard and to collect spillage. Familiarity with permissible ammonia effluent discharge limits for areas of operation including international, national, regional, and local limits and restrictions. Discharge limits may be based on ammonia concentrations. Familiarity with discharge reporting and recordkeeping requirements. **Training programme should encompass imparting understanding on:** ↗ Regulations and requirements for various locations including port waters including discharge limits and reporting. ↗ Emergency response procedures including spill containment.	●	●	●	●	PA. TM. SP.
B17	Waste offloads	Based on local facility capabilities, understanding methods for collecting and packaging residual ammonia and ammonia related waste as required by environmental regulations. **Training programme should encompass imparting understanding on:** ↗ Vendor and port requirements. ↗ Restrictions for waste offloads with ammonia contamination.	●			●	TM.

4. Table C: Ammonia as Fuel: Occupational Health & Safety

This section provides the proposed competencies and associated training standards for occupational health and safety as it relates to carrying ammonia as fuel on board ships. It provides suggestions for new or modified competencies and training above and beyond those that exist for conventional fuel oil operations. This section includes:

- Properties of ammonia affecting human health and health hazards.
- Measurement of ammonia.
- Potential for safety hazards to impact human health.
- Safety related equipment including gas detectors, specialised equipment / devices and personal protective equipment (PPE).
- Work practices – safety support.
- Chemical safety.
- Safety support for nitrogen.
- Safety provisions for exhaust exposures.
- Rescue of personnel in ammonia spaces.
- Safe handling of ammonia including decontamination.
- Safe havens / refuges.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C1	Properties of ammonia affecting human health	Knowledge of physical and chemical properties of ammonia that are detrimental to human health. This can include: ↗ Toxicity. ↗ Flammability / explosivity. ↗ Asphyxiation / oxygen displacement. ↗ Chemical exposures to ammonia or supporting chemicals. ↗ Low temperature. ↗ High pressures. ↗ Emissions (particulate matter / NOx / N_2O / ammonia slip). **Training programme should encompass imparting knowledge on:** ↗ The most recognised hazard is toxicity. ↗ How to recognise the potential for exposures. ↗ Various exposure windows, criteria and thresholds. ↗ Consequences of exposure to various properties. ↗ Steps to prevent or mitigate exposure including use of PPE.	●	●	●	●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C2	Health hazards	Understanding of the health hazards associated with ammonia, recommended precautions and best practices to prevent harm. Exposures can result in: ↗ Toxicity. ↗ Respiratory irritation, asphyxiation. ↗ Skin and eye irritation, severe burns. Understanding the types of situations that could lead to exposures such as leaks, maintenance tasks, venting, entering into restricted areas where ammonia could be present, etc. Understanding of the effects of exposure of ammonia to the eyes, skin, respiratory tract and oral ingestion. Understanding of precautions to prevent exposure to ammonia and steps to be taken to minimise the impact on health in the event of accidental exposure. Understanding acute versus chronic health impacts based on exposure and first aid treatments. Understanding of situations where ammonia can displace oxygen and cause rapid suffocation. Understanding that the low temperatures associated with refrigerated and semirefrigerated ammonia can cause frostbite in the event of direct exposure as well as indirect contact. Understanding that the pressures associated with pressurised ammonia can cause injury in the event of accidental release. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties. ↗ Precautions to prevent or minimise the impact of ammonia exposures including avoidance, gas detection, safe work practices, task planning, PPE. ↗ Exposure thresholds and limitations. ↗ Steps to be taken to minimise the impact, such as first aid, on health in the event of accidental exposure.	●	●	●	●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C3	Measurement of ammonia	Understanding of how toxicity from ammonia exposure is measured for occupational health and safety reasons. Understanding that toxic ammonia exposure is influenced by concentration, exposure duration and route of exposure (in the human body). Knowledge of the three levels associated with Acute Exposure Guideline Levels (AEGL) based on time and concentration (ppm). Knowledge of measures of acute and time weighted concentrations (ppm) such as: ↗ Permissible exposure limit (PEL). ↗ Recommended airborne exposure limit (REL). ↗ Three levels of threshold limit value (TLV), relating to exposure over a working life without adverse effects. 1. Time weighted averages (TWA) 2. Short term exposure limit (STEL) 3. Ceiling concentration (C) not to be exceeded during an exposure. **Training programme should encompass imparting knowledge on:** ↗ The measures used to indicate ammonia. ↗ Potential routes for exposure including inhalation, ingestion, contact with eyes or skin. ↗ The acute exposure guideline levels (AEGL 1, AEGL2 and AEGL3) threshold levels of ammonia leak. ↗ Various measures based on ammonia concentration and time including TLV. ↗ Odour threshold in humans is 1 – 50 ppm but that odour cannot be used as a reliable metric.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C4	Potential for safety hazards to impact human health	Knowledge of ammonia safety properties – such as potential for accumulation of ammonia in enclosed spaces, potential for BLEVE or implosion, potential for vacuum, flammability, vapour cloud formation and dispersion. Knowledge of the low temperatures associated with refrigerated and semirefrigerated ammonia, and high pressures associated with pressurised ammonia. Knowledge of ammonia vapour although lighter than air, the presence of moisture can form the vapours to be heavier than air resulting in accumulation in lower areas of spaces. Knowledge of the possibility of ammonia in storage tanks to create an explosion and BLEVE. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties. ↗ Methods to prevent or minimise the impact of ammonia including monitoring parameters, early intervention, ventilation and gas detection. ↗ Parameter thresholds.	●	●	●	●	PA. TM. SP.
C5	Safety related equipment – showers / eye wash	Understanding the need to ensure that shipboard emergency eye wash fountains and decontamination showers should be available in the immediate vicinity of any potential exposure. If permanent fixtures are not available, understanding the requirements and capacities for temporary equipment. **Training programme should encompass imparting knowledge on:** ↗ Process for confirming or determining where and when eye wash and safety shower stations will be needed. ↗ Need to periodically test and maintain such equipment. ↗ Methods for erecting temporary stations.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C6	Safety equipment – ammonia gas detectors	Understanding of the proper use of gas detection equipment onboard and interpretation of the readings for toxicity and flammability of the atmosphere. Understanding of gas detection monitoring arrangement and responses to ammonia gas detection. Familiarity with detection thresholds and alarm setpoints associated with human exposure to ammonia. **Training programme should encompass imparting knowledge on:** ↗ Various types of ammonia detectors: fixed, portable, personal. ↗ Parameter thresholds including concentrations, TLVs, AEGLs, temperatures, pressures. ↗ Test and calibration requirements for detectors. ↗ Difference between ammonia system detector and those used for other gases.	●	●		●	
C7	Gas detection – ammonia versus various gases	Understanding of the unique aspects related to the detection of ammonia versus other types of gases. Understand various types of gas detectors and interaction (not interference) with other gas detectors (e.g., CO_2, O_2 etc.). For example, requirements for personal detectors for ammonia but also for oxygen (for asphyxiation). Understanding of the various threshold levels where exposure affects human health. Understanding of how to read and interpret detectors. For example, PPM and %vol for toxicity. %vol, %LEL for flammability. **Training programme should encompass imparting understanding on:** ↗ Gas detection system specification, design, layout and relevant control and monitoring requirements ↗ Occupational health related information related to concentration, TLV, AEGL, time windows and first aid measures for exposure.	●	●	●	●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C8	Safety related equipment – ammonia spaces	Understanding that shipboard local exhaust ventilation is recommended to maintain vapour level below the threshold limit value (TLV). Familiarity with the use of ventilation for spaces where ammonia could be present. Knowledge of the effect of ventilation on the ability of gas detectors to detect ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ Purpose, capabilities and limitations of the ventilation system. ↗ Means for detecting and monitoring ammonia vapours.	●	●		●	
C9	Work practice safety support	Understanding the need to incorporate established work practices to reduce the potential for ammonia exposures such as: ↗ Hazard information and training, especially for visitors. ↗ Hazard information and training for contractors or personnel who are temporarily assigned to the vessel and will join for a voyage. ↗ Aspects of ammonia safety in visitor familiarisation protocols. ↗ Monitor airborne concentrations. ↗ Controls if concentrations exceed recommended exposure levels such as alerts. ↗ Isolation of the source of vapours or liquids. ↗ Evacuate areas secure and control access. ↗ Ventilate area. ↗ Provide eye wash fountains and emergency showers. ↗ Special training to wash contaminated clothing. ↗ If there are heat concerns, ensure tanks are kept cool. **Training programme should encompass imparting understanding on:** ↗ Familiarisation/training procedures and materials for visitors and contractors. ↗ Ammonia exposure criteria. ↗ Controls/process if ammonia levels are detected where harmful exposures could occur.	●	●		●	TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C10	Chemical safety – ammonia	Knowledge of the chemical properties of ammonia and its reactivity with other substances. Familiarity with the safety data sheet (SDS) for ammonia. **Training programme should encompass imparting knowledge on:** ↗ Purpose and use of SDS. ↗ Chemical symbols and markings. ↗ Medical first aid guide for dangerous substances (MFAG) for use in accidents involving dangerous goods if applicable. ↗ Where to obtain information about potential actions to mitigate effects of exposures, such as first aid. In some cases (like methanol if is onboard), information about the use of antidotes.	●	●	●	●	PA. TM. SP.
C11	Safety for support chemicals	Knowledge of the chemical properties of specific support chemicals and its reactivity with other substances. This could include citric acid for ARMS, glycol for refrigeration and / or methanol for hydrates. Knowledge of chemical symbols and marking including those for chemicals used to support ammonia system operations. Familiarity with safety data sheets and their use in obtaining information about substances, their characteristics, their hazards, needs for protection and first aid information. This could include treatments or antidotes information. Familiarity with medical first aid guide for dangerous substances (MFAG) for specific support chemicals. **Training programme should encompass imparting knowledge on:** ↗ Use of SDS and MFAG for specific chemicals utilised in supporting storage and handling of ammonia as fuel. This could include glycol, citric acid, etc.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C12	Safety for support gases nitrogen	Understanding the health implications and safety concerns associated with the use of nitrogen. The nitrogen could be provided via compressed cylinders or a nitrogen generation system. Hazards include: ↗ Asphyxiation. ↗ Oxygen Displacement. ↗ Physical and mental impairment. ↗ Cold burns / frostbite. ↗ Potential to sink and collect in low lying spaces. ↗ Pressure hazards if stored as a compressed gas. ↗ Potential to explode if heated. **Training programme should encompass imparting knowledge on:** ↗ Various potential health effects associated with nitrogen. ↗ Sources of nitrogen and tendency of nitrogen to gather in low lying spaces. ↗ Detection of nitrogen. ↗ PPE requirements. ↗ First aid measures.	●	●		●	PA. TM. SP.
C13	Nitrogen familiarisation	Familiarity with the health implications and safety concerns associated with the use of nitrogen. The nitrogen could be provided via compressed cylinders or a nitrogen generation system. **Training programme should encompass imparting knowledge on:** ↗ Various potential overall health effects associated with nitrogen. ↗ Sources of nitrogen and tendency of nitrogen to gather in low lying spaces. ↗ Detection of nitrogen. ↗ PPE requirements. ↗ First aid measures.			●		

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C14	Safety provisions to avoid exhaust exposures	Understanding of the potential for human exposure to emissions of ammonia in the exhaust gases from shipboard propulsion plants, power generators, auxiliary boilers and gas combustion units (GCU). **Training programme should encompass imparting knowledge on:** ↗ Potential exhaust locations and effects of exposure. ↗ Means to reduce the potential for exposure such as establishing safety zones and using engineering systems. ↗ Means for detecting and measuring ammonia or other relevant gases. ↗ Response to exposure to emissions.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore

C15	Specialised safety equipment or devices	Overall knowledge of various specialised equipment or devices used in ammonia service and the conditions/circumstances for their use. This knowledge should be appropriate to the individual's role and responsibilities.
		
		The equipment or devices could include but are not limited to:
		
		↗ Breathing apparatus, aides or devices. Type will be dependent on anticipated and confirmed conditions, ammonia concentrations and task time requirements. These may include:
		  ↗ Escape hoods / packs.
		  ↗ Chemical cartridge respirator with appropriate filters and depending on concentration with a fullface shield.
		  ↗ Supplied air respirator in a continuous flow mode.
		  ↗ Powered, airpurifying respirator with appropriate cartridge(s).
		  ↗ Airpurifying, fullfacepiece respirator (gas mask) with a chinstyle, front or backmounted canister.
		  ↗ Selfcontained breathing apparatus SCBAs with a fullface piece.
		  ↗ Air supplied respirator with a fullface piece.
		↗ Protective clothing including that for working with cold temperatures from ammonia.
		↗ Protective clothing for working in humid climates but that provides protection from ammonia exposure.
		↗ Eye and skin protection – items such as goggles, face shields, gloves, chemical protective clothing, footwear, etc. made of appropriate materials for use around ammonia.
		↗ Resuscitators.
		↗ Rescue and escape equipment for tanks, enclosed or machinery spaces.
		↗ Firefighting bunker gear for ammonia fires.
		↗ Appropriate PPE for emergency response to toxic leaks or spills. This includes any anticipated ammonia handling.
		Training programme should encompass imparting knowledge on:
		
		↗ Safety and emergency equipment to support ammonia operations and maintenance tasks for normal and emergency situations.
		↗ Company procedures and PPE use matrix.
			●	●	●	●	PA.
							TM.
							SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C16	Personal protective equipment (PPE) operations	Understanding the PPE requirements suitable for handling ammonia, and in carrying out preemptive checks to ensure its integrity. Knowledge of PPE requirements for entering and working in various situations, locations and within established safety zones. Understanding of the various levels (Level A, B and C) of PPE suitable for use with ammonia including which level to use for particular operations. Ability to determine the risk and hazards associated with tasks and the level of PPE required. Familiarity with donning and removal of PPE suitable for ammonia. Familiarity with PPE requirements in order to ensure that PPE material is compatible with expected conditions: chemical exposure and temperatures. **Training programme should encompass imparting knowledge on:** ↗ Various levels of PPE and circumstances for their use. This would include Levels A, B, and C. This can include chemical protection or gas tight clothing. ↗ Various types of breathing devices, coverings, gloves, footwear, etc. ↗ Requirements for stowage of PPE and any maintenance. ↗ Methods for decontamination or discard after use. ↗ Company procedures and PPE use matrix.	●	●	●	●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C17	PPE – emergency responders to a leak or spill	Understanding that emergency gear and/or PPE requirements for personnel involved in working as emergency responders in case of ammonia leakage or spill. This may include: ↗ Chemical resistant gastight clothing and a selfcontained breathing apparatus (SCBA) for emergency responders who need to access contaminated areas in order to make the system safe. ↗ Chemicalresistant gastight protective clothing, boots and gloves to a recognised standard for those directly handling ammonia. Appropriate breathing protection. ↗ Selfcontained positive pressure airbreathing apparatus incorporating a fullface mask to be available for those needing to quickly escape to a safe area. ↗ In the case of a leak, short duration selfcontained breathing apparatus such as EEBDs for escaping to a safe location / safe haven / refuge. **Training programme should encompass imparting knowledge on:** ↗ Company requirements, such as a matrix, outlining the emergency response gear and/or PPE to be used under various emergency circumstances from a leak to a spill. ↗ Proper procedures for donning or removing protective gear/ equipment. ↗ Decontamination or waste procedures for gear/equipment used for responding to a leak or spill.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C18	Protective equipment for firefighters	Understanding that those responding to a shipboard ammonia fire must wear suitable protective clothing, gloves and eye/face protection to prevent ammonia exposure. This includes wearing selfcontained breathing apparatus until the fire has been extinguished. Understanding that only approved supplied air or selfcontained breathing apparatus operated in positive pressure mode are satisfactory, if exposure can exceed the exposure limit value. Understanding the specific requirements of PPE and emergency gear to be utilised with ammonia fires. Ability to determine level of protection (Levels A or B) based on fire conditions and firefighting time requirements. **Training programme should encompass imparting knowledge on:** ↗ Various protective gear / equipment configurations to be used during firefighting and during recovery and decontamination phases after the fire.	●	●	●	●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C19	Rescue of personnel in ammonia spaces	Understanding the need to monitor personnel entering and/or working in shipboard spaces where ammonia could be present such as FPRs, TCSs or other locations where emergencies can occur. At minimum, understanding the need to reduce exposure including quickly removing the person from the affected areas. Ability to assess situation and determine PPE needs of rescue team and / or the person being rescued. Familiarity with any special measures to rescue personnel safely and with due consideration given to the safety of the rescue team. Familiarity with written instructions for first aid such as those in the MFAG or other written instructions. **Training programme should encompass imparting knowledge on:** ↗ Safe work practices including enclosed/confined space entry. ↗ Rescue equipment including any required PPE. ↗ First aid measures to be utilised including temporary measures.	●	●	●	●	
C20	Safe handling of ammonia systems, equipment or components	Understanding the provisions for the safe handling of ammonia or items contaminated by ammonia including: ↗ Avoiding breathing dust/fumes/gas/mist/vapours/spray that could have been in contact with ammonia. ↗ Company safe work practices such as those related to hot work where there is a potential for the presence of ammonia or ammonia residues. ↗ Wear suitable respiratory equipment if there could be insufficient ventilation. ↗ Washing contaminated clothing before reuse. ↗ Ensuring contaminated work clothing is not allowed outside of the workplace and cleaned or disposed on appropriately. **Training programme should encompass imparting knowledge on:** ↗ Safe handling practices for ammonia as outlined in the SDS.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
C21	Decontamination	Understanding the overarching principles for providing protection and if needed, first aid to those exposed during decontamination efforts. Knowledge of decontamination requirements for tools, equipment, and substances after exposure. Familiarity with written instructions for first aid such as those in the SDS, MFAG or other written instructions **Training programme should encompass imparting knowledge on:** ↗ Steps to protect seafarers and any other personnel conducting cleanup efforts after an emergency. ↗ First aid requirements for any exposures. ↗ Decontamination processes for items used during emergency response.	●	●	●	●	TM. SP.
C22	Safe havens / refuges	Understanding of the purpose of the safety measures of providing safe havens / refuges such that people are protected from the effects of a major ammonia release. These may be used as a preventive measure during certain operations like bunkering or as an emergency response/evacuation measure. NOTE: This safety measure is under development in the IMO Interim Guidelines for Ships using Ammonia as fuel. **Training programme should encompass imparting knowledge on:** ↗ Qualifying factors for designation of a safe haven / refuge. ↗ Measures required to maintain the integrity/safety of the space. ↗ Emergency response requirements to detect and respond if the space is breached or no longer habitable.	●	●	●	●	PA. TM. SP.

5. Table D: Ammonia as Fuel: Operational / Process Safety

This section provides the proposed competencies and associated training standards for operational and process safety as it relates to carrying ammonia as fuel on board ships. It provides suggestions for new or modified competencies and training above and beyond those that exist for conventional fuel oil operations. This section includes:

1. General operational risks
2. Pressure and temperature variables
3. Operational safety
4. Process safety and other factors.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D1	General operational risks	Understanding of potential risks associated with ammonia operations based on the physical and chemical properties of ammonia. (See Table A above) **Training programme should encompass imparting knowledge on:** ↗ Physical and chemical properties of ammonia. ↗ Inherent hazards associated with ammonia in liquid and gaseous phases.	●	●	●	●	PA. TM.
D2	**Pressure and Temperature Variables**						
D2.1	Health hazards – temperature and pressure	Understanding the health consequences of failing to maintain required temperatures and pressures onboard leading to over pressurisation of piping systems leading to potential ruptures and leaks. **Training programme should encompass imparting knowledge on:** ↗ Injury from exposure to low temperature ammonia release. ↗ Injury from the release of a highpressure jet stream of pressurised ammonia and potentially from flying debris. ↗ Asphyxiation and toxicity hazard of ammonia released in a closed or an open space.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D2.2	Pressuretemperature dynamics	Understanding the pressure and temperature conditions associated with different phases of ammonia. Understanding the effect of the combined variation of pressure and temperature on phase boundaries. **Training programme should encompass imparting knowledge on:** ↗ Ammonia phase diagram including the phase boundaries, triple point and critical point. ↗ The variation of pressure and temperature on the density of ammonia. ↗ The effect of change in temperatures and pressures on the phase stability. ↗ Standard pressures and temperatures for typical refrigerated, semirefrigerated and pressurised storage conditions.	●	●		●	TM. SP
D2.3	Low temperatures impacts	Understanding the risks of handling low temperature conditions for refrigerated and semirefrigerated ammonia storage systems. Familiarity with insulation requirements and low temperature materials used for storage. **Training programme should encompass imparting knowledge on:** ↗ Hazards related to low temperature and precautions in preventing accidental contact. ↗ Potential for embrittlement.	●	●		●	TM. SP
D2.4	Pressure variations in operations	Understanding the tolerances in pressure variations in refrigerated, semirefrigerated and pressurised storage conditions. **Training programme should encompass imparting knowledge on:** ↗ The parameters to be monitored and the permitted range for ammonia in refrigerated, semirefrigerated and pressurised storage conditions.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D2.5	Pressurised storage	Understanding the risks of handling pressurised conditions with pressurised ammonia storage and handling systems. **Training programme should encompass imparting knowledge on:** ↗ Pressure rating parameters of storage tanks, piping, valves, fittings and other equipment. ↗ Maximum operating values of parameters, and their allowable tolerances. ↗ Hazards related to handling high pressures and precautions to avoid injury in the event of accidental contact.	●	●		●	TM. SP
D2.6	Temperature and pressure variations and tolerances	Understanding the implications of temperature and pressure on ammonia systems falling outside the allowable tolerances. **Training programme should encompass imparting knowledge on:** ↗ The pressure/temperature balance of liquified ammonia. ↗ Tolerances in temperature and pressure variations for the specified storage/handling condition. ↗ Preventive actions to prevent the occurrence. ↗ Consequences of nonconformance such as vapour generation, increased pressures, lifting of pressure relief valves, leaks or ruptures.	●	●		●	TM. SP
D2.7	Heat ingress	Understand the implications of heat ingress on ammonia storage and handling systems. **Training programme should encompass imparting knowledge on:** ↗ Thermal insulation requirements of ammonia storage and handling systems. ↗ Boil Off Gas (BOG) management.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D2.8	Pressuretemperature dynamics factors	Understanding the factors that influence the generation of boil off gas in refrigerated and semirefrigerated ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Insulation of ammonia storage, transfer piping and handling equipment. ↗ Effect of ambient temperature on storage and handling arrangements. ↗ Effect of conductive and radiative heat transfer.	●	●		●	TM. SP
D2.9	Boil off gas	Understand the characteristics of boil off gas (BOG) and boil off gas management. **Training programme should encompass imparting knowledge on:** ↗ The factors which can adversely affect the rate of generation of boil off gas. ↗ Parameters that need to be monitored and controlled to minimise the generation of boil off gas. ↗ Typical design and layout of BOG management systems.	●	●		●	TM. SP
D3	**Operational safety**						
D3.1	Over pressure prevention	Understanding the factors that can lead to overpressurisation of the system, and preventive measures to avoid occurrence. **Training programme should encompass imparting knowledge on:** ↗ The relationship between temperature and vapour pressure of ammonia vapours. ↗ The factors that can adversely affect the rate of boil off gas generation. ↗ Measures to ensure the reliability of boil off gas management equipment.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.2	Over pressure impacts	Knowledge of the potential impacts of overpressurisation on the storage tanks, piping, valves and associated mountings. **Training programme should encompass imparting knowledge on:** ↗ Maximum allowable and safe working pressure of storage tanks, piping, valves and associated mountings.	●	●		●	TM. SP
D3.3	Pressure relief systems	Familiarity with the system pressure relief valves (PRV), devices and vents. **Training programme should encompass imparting knowledge on:** ↗ Design basis and standards related to relief systems. ↗ Arrangement of the pressure relief valves (PRV) and devices related to ammonia system on board the ship. ↗ Location of vent openings and vent masts, and safety considerations at these locations. ↗ Locations of toxic spaces and toxic areas onboard in relation to pressure relief systems. ↗ Closed relief headers or systems. ↗ Potential for leak detections at vent masts.	●	●		●	TM. SP
D3.4	Temperature conditioning	Understanding of the requirements of temperature conditioning of empty tanks in preparation for loading liquified ammonia as fuel. **Training programme should encompass imparting knowledge on:** ↗ Temperature conditioning of storage tanks to avoid thermal stress. ↗ The purpose of “heel” to condition an empty tank to a temperature equivalent to the ammonia being bunkered/ transferred.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.5	Vapour generation	Understanding the management of vapour generation during bunkering and storage operations. **Training programme should encompass imparting knowledge on:** ↗ The system arrangement on board the ship for managing vapour during bunkering including vapour return line arrangements.	●	●		●	TM. SP
D3.6	Leaks due to equipment malfunction	Understanding of the response in the event of an equipment malfunction that has the potential to lead to ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ System design and builtin redundancies for safe isolation. ↗ Troubleshooting and safe isolation to control the source of leak. ↗ Contingency plans for anticipated scenarios of ammonia leaks.	●	●		●	
D3.7	Mitigation of operational releases	Understanding of the design and operation of systems installed for mitigating the operational release of ammonia. **Training programme should encompass imparting understanding on:** ↗ Ammonia Release Mitigation System (ARMS) system specification, design, layout and relevant control and monitoring requirements.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.8	Ventilation of spaces strategy	Understanding of the strategy to be adopted with shipboard ammonia systems in achieving a safe atmosphere in terms of toxicity and flammability. **Training programme should encompass imparting knowledge on:** ↗ The ventilation strategy in spaces to ensure the atmosphere remains outside the toxicity and flammability range of ammonia in the event of a leak. ↗ The ventilation strategy to ensure the effective evacuation of ammonia vapours from spaces in the event of a leak.	●	●		●	
D3.9	Ventilation of spaces – design and arrangements	Understanding the ventilation design arrangement of onboard spaces containing ammonia systems in terms of leak detection and vapour dispersion capabilities. **Training programme should encompass imparting knowledge on:** ↗ The optimal air changes in spaces containing ammonia systems to ensure the detection of leaks, and for effective dilution of ammonia vapour.	●	●		●	
D3.10	Cautions related to venting and vent masts	Knowledge of the risk of ammonia exposure with operational venting of ammonia at the vent mast. **Training programme should encompass imparting knowledge on:** ↗ Physical and chemical properties of ammonia. ↗ Toxicity hazard of ammonia. ↗ Dispersion characteristics of ammonia vapour clouds and their influencing factors. ↗ Potential impact of weather including wind speed, direction, humidity, etc. ↗ Controlled zones on the ship, and the requirements within each of these zones.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.11	Ammonia fire detector failure	Understanding of the shipboard measures to be implemented in the event of failure of ammonia fire detectors. **Training programme should encompass imparting knowledge on:** ↗ Risk assessment of anticipated scenarios with loss of one or more ammonia fire detectors, or the entire fire detection system. ↗ Mitigation measures to be implemented/followed in case of failure of ammonia related devices such as a fire detector, a fire detection loop or the entire fire detection system.	●	●		●	
D3.12	BLEVE	Understanding the potential of ammonia under storage to cause Boiling Liquid Expanding Vapour Explosion (BLEVE). **Training programme should encompass imparting knowledge on:** ↗ Storage conditions that can lead to the potential of BLEVE. ↗ Parameters that need to be monitored for the prevention of BLEVE.	●	●		●	TM. SP
D3.13	Nitrogen	Understanding of the shipboard safety aspects of nitrogen utilised for inerting operations with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ The processes where nitrogen is utilised in ammonia systems including purging of fuel supply and return lines. ↗ Hazards associated with nitrogen when utilised as inert gas. ↗ Design requirements on placement of nitrogen generators and storage tanks/cylinders on board.	●	●		●	
D3.14	Hydrates	Understanding the potential of hydrate formation in ammonia systems, and preventive measures to avoid occurrence. **Training programme should encompass imparting knowledge on:** ↗ The factors that can promote the formation of hydrates of ammonia in ammonia systems.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.15	Materials of construction	Understanding the materials for construction of storage tanks, piping systems and mountings. **Training programme should encompass imparting knowledge on:** ↗ Materials of construction utilised for the construction of storage tanks, piping, valves, fitting and other items of equipment normally in direct contact with ammonia liquid or vapour. ↗ Material compatibility with repair processes such as hot and cold work.	●	●		●	TM. SP
D3.16	Insulation	Understanding the characteristics of thermal insulation materials utilised in refrigerated and semirefrigerated ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Thermal insulation materials and specifications utilised in ammonia storage tanks and handling arrangements. ↗ Criteria for identification of deterioration of insulation from the specified acceptable standard.	●	●		●	TM. SP
D3.17	Impurities	Understanding the effect of impurities in ammonia that can adversely affect operational performance including safety. **Training programme should encompass imparting knowledge on:** ↗ The quality specification of ammonia acceptable as a marine fuel. ↗ The maximum absolute value of acceptable impurity levels. ↗ The maximum acceptable value of individual impurities. ↗ The effect of individual impurities on the stability and reactivity of ammonia in liquid and gaseous phases, and on the phase boundaries.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D3.18	Ambient temperature	Understanding the ambient temperature range for spaces onboard containing ammonia storage tanks, piping and equipment. **Training programme should encompass imparting knowledge on:** ↗ The effect of ambient temperatures in spaces containing ammonia systems. ↗ The working ambient temperature for spaces with ammonia systems.	●	●		●	
D3.19	Safety related equipment – ammonia exposures	Understanding special safety related equipment or features to prevent or reduce the potential of exposures from leaks in ammonia spaces such as the tank connection space (TCS), FPR or Engine Room. Familiarity with the location of the potential sources of leaks based on the specific vessel design. **Training programme should encompass imparting knowledge on:** ↗ Ammonia detectors / leakage detection. ↗ Automatic closing of isolation valves or the ability to cut off the supply of ammonia to the leakage source. ↗ Proper mechanical shielding of all leakage points in the space to reduce the risk of direct exposure to ammonia. ↗ Ventilation and venting systems. ↗ If permitted and required, air locks on entrances to spaces of concern such as TCS, FPR, etc.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D4	**Process safety and other factors**						
D4.1	Process safety management	Understanding the need to broaden the concept of safety beyond occupational health and safety to encompass process safety. **Training programme should encompass imparting knowledge on:** ↗ Using a risk management approach to prevent or minimise the consequences of catastrophic releases of toxic, reactive, flammable or explosive chemicals. ↗ Controlling activities related to ammonia operations including bunkering, storage, handling, transfer, use or emergency response. ↗ Thresholds related to adverse effects of ammonia based on its properties or chemistry.	●			●	
D4.2	Process safety information	Provision of information to seafarers, appropriate to their role, with regards to the potential hazards associated with ammonia. **Training programme should encompass imparting knowledge on:** ↗ Information related to how to recognise and avoid hazards such as catastrophic events such as toxic release, reactive conditions, fires or explosion. ↗ Systems, equipment and components in ammonia service, as well as their locations. ↗ Information about the technology employed to control ammonia or its impacts. ↗ Restrictions for interfacing with ammonia or systems in ammonia services. ↗ Use of PPE appropriate to various situations.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D4.3	Written processes and procedures	Ability to understand and interpret written operational procedures using both theoretical and practical knowledge of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Chemical and physical properties of ammonia. ↗ Ammonia system design and layout including related safety systems and their functions. ↗ Ammonia hazards. ↗ Means to operate the ammonia system within designated parameters. ↗ Emergency response for offnormal conditions.	●	●			
D4.4	Management of change	Ability to monitor conditions, identify and then manage any changes to conditions. Ability to make potential adjustments to operations to maintain acceptable conditions. **Training programme should encompass imparting knowledge on:** ↗ MOC processes including hazard / risk identification and change acceptance criteria. ↗ Types of changes (temporary and permanent), risk assessment process, and administrative requirements for documenting the changes.	●	●			PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D4.5	Interactions with other substances	Understanding of the effect of the interaction of ammonia with other substances. **Training programme should encompass imparting knowledge on:** ↗ Chemical and physical properties of ammonia. ↗ Effect of substances such as moisture in air prior to combustion in an internal combustion engine. Note: the unique hazard of moisture for anhydrous ammonia. ↗ Effect on lubricants used in equipment within ammonia systems. ↗ Effect of ammonia vapours or liquids on certain metals or materials.	●	●		●	
D4.6	Sources of ignition	Understanding the principle that sources of ignition, including electrical sources, should be avoided though there is nothing unique for ammonia fuelled vessels. **Training programme should encompass imparting understanding on:** ↗ Electrical system design and classification principles. ↗ Precautions related to relevant ignition sources.	●	●		●	
D4.7	Electrical equipment	Understanding the classification of zones within the ship and the implication on the requirements for electrical equipment and fittings. Understanding of requirements for electrical classification of equipment and fittings associated with ammonia systems. Understanding of electrostatic hazards including those associated with static electricity and energy accumulators and generators. **Training programme should encompass imparting understanding on:** ↗ Overall electrical system design, classification and precautions, though no unique aspects are required for ammonia itself.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
D4.8	Mechanical equipment	Understanding the classification of zones within the ship and the implication on the requirements for mechanical equipment and fittings. Understanding of requirements for classification of mechanical equipment associated with ammonia systems. **Training programme should encompass imparting understanding on:** ↗ Mechanical systems and equipment associated with the ammonia fuel system. ↗ Potential mechanical systems, including lifting appliances, to impact ammonia fuel operations.	●	●		●	
D4.9	Automation	Understanding of the automated process flow of systems associated with ammonia as a fuel, and the system requirements for human intervention in the event of automation failure. **Training programme should encompass imparting understanding on:** ↗ Ammonia chemical and physical properties including temperature/pressure relationships. ↗ Automated processes and features. ↗ Company procedures for responding to loss of automation.	●	●		●	

6. Table E: Ammonia as Fuel: Regulations, Local requirements, Industry guidelines

This section provides the proposed competencies and associated training standards for future ammonia regulations, local requirements and industry guidelines. The information provided is based on what was anticipated at the time of the publication of this document. This section includes:

1. International requirements and industry guidance
2. Local regulations and requirements
3. Preparations for port operations
4. Procedures for mooring operations
5. Procedures for port authority or terminal recordkeeping

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
E1	International requirements and Industry guidance	Familiarity with applicable International Regulations and industry guidelines. This would include MARPOL and other international codes as applicable IGC, IGF, ISM, as well as Class Rules. Guidance from recognised Industry bodies SGMF, OCIMF, SIGTTO, ISO, etc. **Training programme should encompass imparting knowledge on:** ↗ Applicable regulatory codes and industry guidance. ↗ Guidance from marine industry documents. ↗ Bunkering guidance and checklists based on industry guidance.	●	●		●	PA. TM. SP
E2	Local regulations and requirements	Understanding of port State, port or terminal regulations and requirements related to the presence of ammonia onboard. This would include marine as well as onshore requirements depending on the location and interfaces with various entities while in port. **Training programme should encompass imparting knowledge on:** ↗ Information needed for pre-planning prior to port entry. ↗ Planning process for any combined operations. ↗ Applicable regulations and requirements.	●			●	PA. TM. SP.
E3	Preparation for port operations	Knowledge of any pre-planning processes for requesting special accommodations from port or terminal for operations related to the ammonia system. Familiarity with documentation requirements related to planned inspections, maintenance, and repairs while in port. **Training programme should encompass imparting knowledge on:** ↗ Information requirements. ↗ Ammonia operations that require additional permissions or accommodations. ↗ Approval or permissions required for operations related to ammonia systems such as maintenance from contractors.	●	●		●	PA

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
E4	Procedures – mooring operations	As with standard mooring arrangement, familiarity with existing guidance such as ISO standards and best practice guidelines for operations planning. This would include any special requirements related to carriage of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Any special permissions or accommodations the vessel carrying ammonia would need. ↗ Industry standards and guidelines.	●			●	TM
E5	Procedures – port authority or terminal reporting	Familiarity with reporting requirements, including to Port Authority, for any planned operations or emergency situations. Awareness of requirements for informing port or terminal of any changes in conditions related to the ammonia systems while in port. **Training programme should encompass imparting knowledge on:** ↗ Any special requirements related to reporting about ammonia carriage, use in port / at terminal or changes to emergency response requirements.	●			●	PA. TM.

7. Table F: Ammonia Fuel Storage, Management and Transfers

This section provides the proposed competencies and associated training standards for ammonia fuel storage, management and transfer operations on board ships carrying ammonia as fuel. It provides suggestions for new or modified competencies and training for ammonia fuel above and beyond those used for conventional fuel oil operations. This section includes:

- Fuel storage
- Fuel handling
- Fuel tanks design, layout and protections
- Fuel monitoring, control and automation
- Dual fuel operations
- Fuel changeover
- Fuel system conditioning
- Handling of ammonia fuel and residues.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F1	Ammonia storage and handling systems – general	Understanding of engineering processes of systems associated with storage and handling of ammonia as a fuel in its different forms onboard ships. This may include refrigeration / liquefaction and /or re-liquefaction. **Training programme should encompass imparting knowledge on:** ↗ Storage systems including tanks and associated safety equipment. ↗ Conditioning systems including pumps, compressors, heat exchangers, vaporiser units, etc. ↗ Tank pressure management system ↗ Associated equipment and re-liquefaction plant (for refrigerated or semi-refrigerated ammonia). ↗ Handling systems including piping, valves, filters and associated instrumentation for monitoring and control. ↗ Safety systems including shutdown, pressure relief valves (PRVs) and other safety mountings. ↗ Instrumentation and controls for managing the storage and transfers.	●	●		●	
F2	Ammonia tank design and layout	Knowledge of storage arrangements and tank configurations. **Training programme should encompass imparting knowledge on:** ↗ Layout and design including materials of construction. ↗ Tanks type (A, B, C), location, construction, design, structure, insulation. This could include independent tanks in the ship's hull or deck mounted tanks. ↗ Pressure control / relief. ↗ Level control. ↗ Tank drain system for residues including separate bilges.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F3	Storage – storage conditions	Understanding the various storage conditions suitable for ammonia as a fuel on board ships. **Training programme should encompass imparting knowledge on:** ↗ Pressurised, semi-refrigerated and refrigerated storage conditions of ammonia in liquid phase. ↗ The temperature and pressure ranges of the storage conditions, and allowable variation limits. ↗ The temperature and/or pressure conditioning requirements of empty tanks prior to initial commissioning or recommissioning after inspection/maintenance.	●	●		●	
F4	Storage – Internal / hull tanks	Understanding the containment and conditioning arrangements for storing ammonia as fuel onboard ships in tanks within the hull. NOTE: Internal tanks located in the hull will be Type A or Type B. **Training programme should encompass imparting knowledge on:** ↗ The types of containment arrangements suitable for the specific storage condition. ↗ Precautionary measures incorporated in the space housing the storage tanks or secondary barriers to mitigate the risk in the event of leaks. ↗ The inspection and maintenance requirements of the specific containment arrangements. ↗ Inspection regimes to validate integrity. ↗ Tank pressure and temperature gauges including their type and accuracy. ↗ Leak detection sensors in spaces containing ammonia storage tanks.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F5	Storage – Type C deck mounted tanks	Understanding the containment arrangements for storing ammonia as fuel onboard ships in a Type C deck mounted tank. **Training programme should encompass imparting knowledge on:** ↗ Insulation arrangement of Type C deck mounted tanks. ↗ Inspection regime to validate insulation integrity. ↗ The processes for connecting and disconnecting components, equipment, piping, and electrical supplies/utilities. ↗ Requirements for preparing for lifting operations that would occur in the vicinity of the Type C deck mounted tank including understanding the protocols associated with the fastening/lifting arrangements for items being moved to reduce the potential for dropped objects and any special ammonia considerations. ↗ Aspects of the Type C deck mounted tank external inspections or that of related tank components. ↗ Securing of Type C deck mounted tanks on board. ↗ Precautionary measures incorporated in the location of Type C deck mounted tanks on open decks to mitigate the risk of damage from falling objects.	●	●		●	
F6	Storage – monitoring	Familiarity with the monitoring of the level, pressure and temperature of ammonia storage tanks. **Training programme should encompass imparting knowledge on:** ↗ Storage tank level, temperatures and pressures related to the storage condition, and allowable operational tolerances. ↗ Types of level, temperature and pressure gauges including their type and accuracy. ↗ Remote and local monitoring of tank parameters such as level, pressure and temperature. ↗ Alarm setpoints and thresholds.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F7	Management – storage tanks	Understanding the management of ammonia as a fuel stored on board ships. **Training programme should encompass imparting knowledge on:** ↗ Managing storage including tank parameters such as pressure and temperature. ↗ Vapour / boil off gas (BOG) management of liquified ammonia and the means of minimising these. ↗ Systems for management of boil off gas including reliquefaction plants. ↗ Systems to maintain the pressure of ammonia including vaporisers to maintain the pressure in low pressure situations. ↗ Monitoring of system parameters critical to maintaining the storage condition of ammonia including pressure and temperature. ↗ Level monitoring of storage tanks including the effect of pressure and/or temperature on the detection of level.	●	●		●	
F8	Management – dual fuel operations	Understanding the operations of dual-fuel operations with ammonia as a fuel. **Training programme should encompass imparting knowledge on:** ↗ Fuel change over from/to ammonia, and the operational precautions during the changeover to ensure a bump less transfer. ↗ System vulnerabilities such as component reliability – those that can affect the fuel changeover to proceed as intended, and in achieving the desired qualitative outcome. ↗ Dual fuel engine limitation with ammonia operations on low loads – system restricts operation on ammonia on low loads.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F9	Fuel changeover	Understanding fuel changeover operation for dual fuel engines. **Knowledge of any preconditions or limitations affecting changeover process and / or decision-making.** ↗ Training programme should encompass imparting knowledge on: ↗ The automated and manual processes associated with fuel changeovers – process for initiating fuel changeovers. ↗ The startup processes for supporting machinery prior to automated fuel change over sequences. ↗ How to operate the related equipment for dual fuel operations such as the supply (high / low pressure) pump, vaporiser, etc, ↗ Controlling changeover processes as necessary and monitoring relevant parameters to gauge changeover progress and finalisation. ↗ How to detect anomalies during changeover and take action to ensure fuel continues to be supplied to or shut off to engines. .	●	●		●	
F10	Storage – safety systems	Understanding the operational and safety limits incorporated in ammonia storage tanks. **Training programme should encompass imparting knowledge on:** ↗ Storage tank operational limits including level, pressure and temperature tolerances. ↗ Safety devices associated with storage tanks, equipment and piping systems to protect against over pressuring or vacuum conditions including PRVs. ↗ Earthing protection of tanks. ↗ Lightning protection of tanks located on open decks.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F11	Storage – quantity monitoring	Familiarity with the monitoring of quantity in ammonia storage tanks. **Training programme should encompass imparting knowledge on:** ↗ The principle of operation of level gauges used in ammonia storage tanks, and their operational limitations. ↗ The factors that affect the measurement of the correct quantity of ammonia in the storage tanks. ↗ Relevance of filling limit, loading limit (max), high liquid level alarm, low liquid level alarm and low-low liquid level alarm. ↗ Connectivity requirements between tank level signals and ESD system. ↗ Familiarity with tank level gauges including their type and accuracy. ↗ Recordkeeping of consumption of ammonia as a fuel if different than past logging processes.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F12	Storage – instrumentation	Understanding of engineered safety systems including indicators, controls and alarms. **Training programme should encompass imparting knowledge on:** ↗ Tank level indication for closed systems. ↗ Working principle and operation of liquid level gauges onboard including: ↗ Indirect systems – weighing or pipe flow meters. ↗ Closed device (without penetration bunker tank) – Ultrasonic or Radio-isotope source ↗ Closed device (with penetration bunker tank) – Float gauges ↗ Restricted device (with penetration bunker tank). ↗ Working principle and operation of level alarms (low, low-low, high and high-high) onboard including: ↗ 95% of tank volume. ↗ 98.5% of tank volume ↗ At 99% of tank volume (high-high level alarm). ↗ Tank pressure indication and control such as pressure relief valves (PRVs). ↗ Temperature indication and control. ↗ Gas leak detection and alarms. ↗ Emergency Shut Down (ESD) systems.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F13	Storage – support system	Understanding the support equipment such as re-liquefaction or nitrogen generation systems associated with ammonia storage arrangement onboard ships. **Training programme should encompass imparting knowledge on:** ↗ The operation of the support equipment associated with the maintenance of specific storage condition including re-liquefaction compressors, heat exchangers, etc. ↗ Re-liquefaction plants for boil off gas management in semi-refrigerated and refrigerated storage conditions. ↗ BOG transfer system for use in other equipment such as boilers. ↗ Instrumentation for monitoring and control. ↗ Nitrogen generation systems including design, system, operational and maintenance requirements. ↗ How to recognise and address automated system failures.	●	●		●	
F14	Handling – system conditioning	Understanding the requirements of system conditioning control for reception and storage of ammonia as a fuel. **Training programme should encompass imparting knowledge on:** ↗ The arrangement of the equipment for refrigerated and semi-refrigerated storage conditions in the re-liquefaction room including the re-liquefaction compressors, condensers, inter-coolers and knock-out drums. ↗ Temperature and pressure monitoring during initial commissioning, isolating for inspection/maintenance or recommissioning, as appropriate to the storage condition. ↗ Atmosphere conditioning of the system prior to restarting operations and inerting of the system with nitrogen to bring the oxygen level to below 4% volume and followed by purging with ammonia vapour until the tank's oxygen is less than 0.5% volume.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F15	Handling – quality monitoring	Understanding the quality monitoring of ammonia as a fuel stored onboard the ship. **Training programme should encompass imparting knowledge on:** ↗ Familiarity with the fuel quality documentation. ↗ Quality specifications for acceptance of ammonia as a fuel. ↗ Process requirements that are essential to retain the quality of ammonia as a fuel during storage and handling on board. ↗ Impurities such as iron particles, nitrogen, moisture, etc that can adversely affect the quality of ammonia as a fuel or cause safety issues in its storage and handling. ↗ Sampling of ammonia liquid for quality monitoring including measuring water and oxygen if required.	●	●		●	
F16	Handling – internal transfers	Understanding the process requirements for ammonia transfers between multiple storage tanks, if present. **Training programme should encompass imparting knowledge on:** ↗ Operational limits of tanks, pumps, piping and mountings associated with tank transfers including level, pressure and temperature tolerances, and transfer flow rates related to ammonia operations. ↗ Arrangement of transfer systems, and the alignment of the system to carry out tank-tank transfers. ↗ Process vulnerabilities that can lead to overpressure, low pressure, vacuum conditions, overfill and leaks. ↗ Conditioning of tanks involved in the transfer acknowledging the potential of change in parameters and atmosphere in the tanks. ↗ The feasibility of transfers from a storage condition to another storage condition, and the system requirements to carry out such transfers. ↗ Management of the support equipment involved in carrying out safe transfers including re-liquefaction plants, vaporisers, heat exchangers, nitrogen generators, etc. ↗ Arrangements to prevent the generation and accumulation of static charges.	●	●		●	

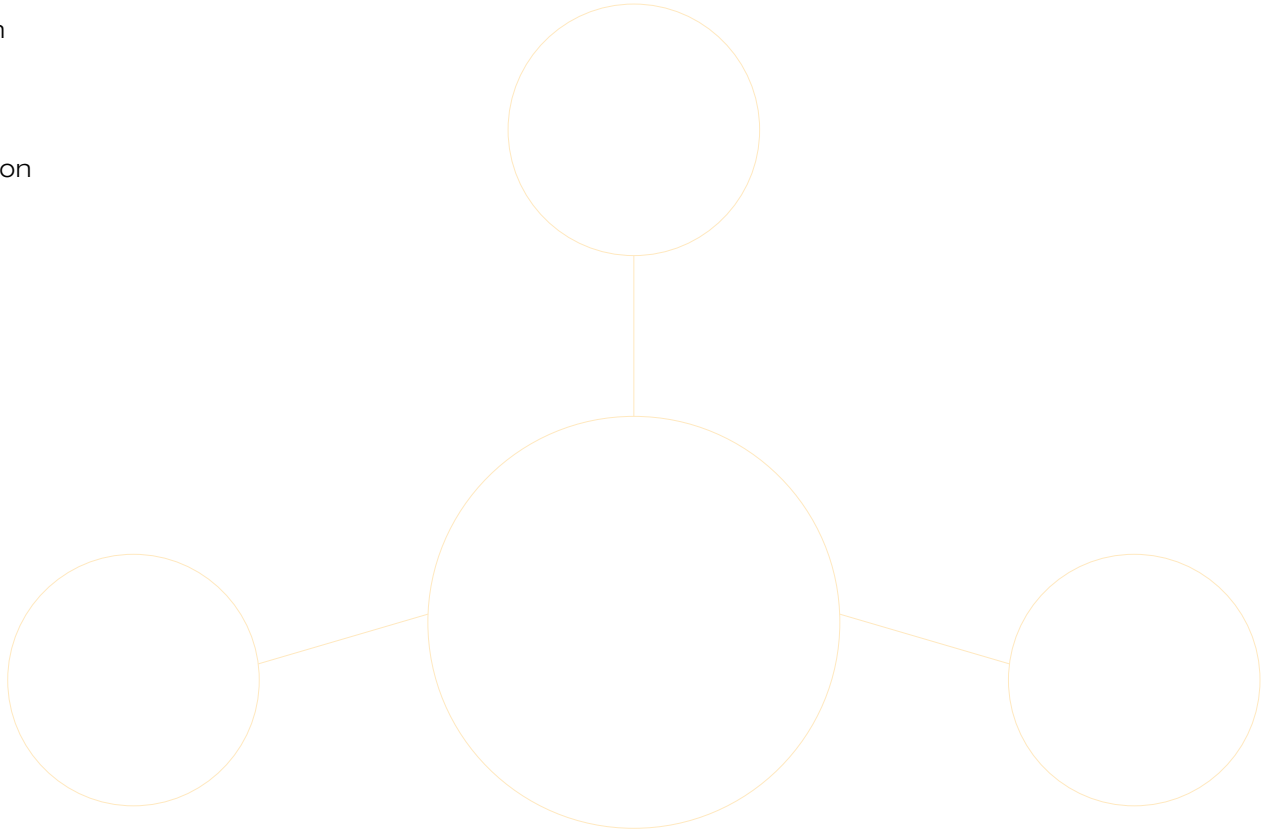
No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F17	Handling – fuel to engines, auxiliaries and other consumers	Understanding the process requirements of supplying ammonia as fuel to the engines, auxiliaries and other consumers. **Training programme should encompass imparting knowledge on:** ↗ Operational limits of tanks, pumps, piping and mountings associated with transfer of ammonia from the storage tank to the engines for consumption as fuel. ↗ Arrangement of transfer system for supplying of ammonia as fuel to the main engines that will include a high-pressure section and low-pressure section. ↗ low pressure section (approximately 20-30 bar) between the storage tank to the high-pressure pump in the FPR, and ↗ high-pressure section (approximately 80 bar) from the high-pressure pump in the FPR to the consumers such as engines. ↗ Arrangement of transfer system for supplying of ammonia as fuel to the auxiliary engines and other consumers. ↗ System controls, safety interlocks, redundancies and fail-safe modes. ↗ The arrangement of the tanks, piping, valves, level sensors, pressure sensors, temperature sensors and instrumentation in the TCS. ↗ The arrangement of pumps, piping, valves, filters, heat exchangers, knock-out drums, recovery tanks, accumulators and safety devices in the fuel preparation room (FPR). ↗ Conditioning requirements for ammonia in preparation for consumption in the engine. ↗ Double-walled pipes with dry air circulation mechanism in the annular space with minimum volume of 30 air changes per hour. ↗ Redundant flow monitoring of dry air in annular space of double walled pipes. ↗ Redundancy in detection of ammonia leak in annular space of double walled pipes. ↗ Pretest of inner ammonia piping with nitrogen pressure to ensure no leak as part of the fuel changeover process. ↗ Double block and bleed valves arrangements including positive isolation and verification. ↗ Arrangements to prevent the generation and accumulation of static charges. ↗ Monitoring of fuel handling and transfer operations. ↗ The purposes of the automation and the risks of overriding automated features. ↗ Operating procedures. ↗ Emergency response procedures.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
F18	Automation and controls	Knowledge of ammonia related systems and the ability to control/ monitor various parameters. **Training programme should encompass imparting knowledge on:** ↗ The types of measuring devices, limitations; set points, alarms and alarm response. ↗ Automated functions and features including system logic. ↗ Control and monitoring systems and functions: ↗ An overview of how control systems work ↗ An overview of how different control systems interact ↗ Control and monitoring functions ↗ Control elements ↗ Alarms and trips. ↗ Use of test / diagnostic mode and ensuring system is restored to correct mode for operation. ↗ Ability to diagnose abnormal trends or events. ↗ The types of patterns of process upsets that may lead to the need to shut in / down the system before a major event. ↗ Parameters: minimum / maximum fuel temperatures / pressures; control/ monitoring / alarms.	●	●		●	
F19	Handling – residues of ammonia	Understanding the process requirements for handling ammonia residues. **Training programme should encompass imparting knowledge on:** ↗ Ensuring fuel supply system or other ammonia containing equipment has been completely emptied and nitrogen purged before opening system. ↗ Function and operation of ammonia catch system and ARMS. ↗ Handling of related ammonia residues. ↗ Handling of ammonia residues generated by purging of equipment and pipe sections with nitrogen. ↗ Handling of ammonia residues from equipment and piping systems.	●	●		●	

8. Table G: Ammonia Gas Purging and Venting from Compartments

This section provides the proposed competencies and associated training standards for ammonia gas purging from compartments and venting on board ships carrying ammonia as fuel. It provides suggestions for new or modified competencies and training for ammonia fuel based purging and venting operations. This section includes:

1. Storage tank – isolation
2. Storage tank – recommissioning after isolation
3. Transfer piping – isolation
4. Transfer piping – recommissioning after isolation
5. Compartments – ventilation
6. ARMS systems
7. Vent masts.



No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G1	Storage tank – isolation	Understanding the process of safe isolation of ammonia storage tanks for inspection and/or maintenance. **Training programme should encompass imparting knowledge on:** ↗ The risks and hazards related to ammonia in storage tanks including toxicity and flammability. ↗ The sequence of operation in isolation of the tank which would include ↗ Precautions for enclosed space / tank entry including JSA / JHA, permitting, etc. ↗ Emptying the tank. ↗ Drying the tank. ↗ Warming-up of the tank. ↗ Inerting the tank atmosphere to prevent the formation of flammable mixtures. ↗ Aeration of the tank to make the tank atmosphere suitable for entry and inspection/maintenance. ↗ The prevention of escape of ammonia to the atmosphere during the purging process. ↗ The risks associated with inerting operations including the inherent hazards posed by nitrogen gas. ↗ The risks associated with improper aeration of the space including gas pockets after inerting including the hazards of asphyxiation. ↗ The risks associated with potential gas levels including ammonia, nitrogen, oxygen, etc. ↗ Prevention measures to reduce potential for thermal stress of tank, piping or insulation materials during warm-up and cool-down of tank.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G2	Storage tank – recommissioning after isolation	Understanding the process of safe recommissioning of ammonia storage tank back into service. **Training programme should encompass imparting knowledge on:** ↗ The operational risks related to ammonia storage tanks including ingress of moisture and other impurities. ↗ The sequence of operation in putting an isolated and vented ammonia storage tank back into service which would include: ↗ Drying of the tank to eliminate moisture. ↗ Inerting the tank atmosphere with dry nitrogen to remove air, moisture and prevent entering the flammable range. ↗ Gassing up the tank with warm ammonia. ↗ Conditioning the tank by cooling down to prevent thermal stress during initial loading of ammonia (refrigerated and semi-refrigerated conditions). ↗ The risks associated with improper cool down of the tank prior to the introduction of ammonia, including thermal stresses that can result from insufficient cooling down of the tank.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G3	Transfer piping – isolation	Understanding the process of safe isolation of ammonia equipment and piping systems for inspection, maintenance or repairs. **Training programme should encompass imparting knowledge on:** ↗ The risks and hazards related to accidental release of entrapped ammonia including skin exposure, toxicity and flammability. ↗ The sequence of operation in isolation of equipment, piping, valves and associated mountings which would include: ↗ Isolation of the specific equipment and/or pipe section ↗ Draining or purging of the remaining ammonia by suitable means including nitrogen gas. ↗ Aeration of the isolated section of piping to make the atmosphere suitable for entry and inspection/maintenance. ↗ The steps to be followed for isolation of a section of the system including positive verification of isolation through provided arrangements such as double block and bleed valve arrangement. ↗ Indications for satisfactory completion of isolation operations such as measurement of ammonia at a suitable location.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G4	Transfer piping – recommissioning after isolation	Understanding the process of safe recommissioning of isolated ammonia transfer piping back into service. **Training programme should encompass imparting knowledge on:** ↗ The operational risks related to ammonia systems including ingress of moisture and other impurities. ↗ The sequence of operation in putting an isolated and vented ammonia piping system back into service which would include: ↗ Leak testing of system with nitrogen before introduction of ammonia ↗ Drying of the pipe section to eliminate moisture. ↗ inerting the pipe section with nitrogen to remove air, moisture and prevent the flammable range. ↗ Pressure testing to check the integrity of the assembled pipe section and associated mounting including valves, gauges, probes and sensors ↗ Gassing up the pipe section with warm ammonia. ↗ Conditioning the piping by cooling down to prevent thermal stress during the initial loading of ammonia (refrigerated and semi-refrigerated conditions). ↗ Precautions to prevent vapour / gas locking with piping during recommissioning ↗ Inspection of the integrity of insulation and its continuity in service. ↗ Final leak check once cold condition is reached.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G5	Compartments – ventilation	Understanding the ventilation arrangements of spaces containing ammonia tanks and handling equipment for ammonia onboard ships. **Training programme should encompass imparting knowledge on:** ↗ The ventilation arrangement in the TCS, FPR as well as reliquefaction room. ↗ The ventilation arrangements for the Engine Room as they relate to the potential for ammonia vapours. ↗ Safety interlocks, automated emergency functions and manual over-ride functions related to ventilation of spaces with the potential of ammonia leaks including TCS, FPR, etc. ↗ Requirements for air changes within compartments. ↗ Location of ventilation outlets including vent masts associated with spaces with the potential for ammonia leaks. ↗ Ventilation requirements for service in hazardous spaces including: ↗ Rating of the electric motor. ↗ Non-sparking construction of components. ↗ Segregation from hazardous spaces. ↗ Safe bonding to hull. ↗ Air lock & over-pressure feature. ↗ Fail-safe fire dampers related to compartments containing ammonia equipment and storage tanks.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
G6	ARMS system	Understanding the ARMS and vent systems onboard ammonia fuelled ships, venting operation and the sequence of these operations. **Training programme should encompass imparting knowledge on:** ↗ The ARMS system supporting and processing the operational venting of ammonia including knock-out drums, recovery tank, water seal, etc., as appropriate. ↗ Capacity of the ARMS system in terms of ammonia venting rate and total quantity. ↗ The function of the ammonia ARMS and vent arrangement. ↗ Sequence of operation for stopping the ammonia supply to the engine and purging with nitrogen. ↗ Sequence of operation for system purging with nitrogen, and ammonia recovery.	●	●		●	
G7	Vent masts	Understanding the function and requirements of vent masts onboard ammonia fuelled ships. **Training programme should encompass imparting knowledge on:** ↗ The location and design of vent masts including independent vent lines – one routed port side and one routed starboard side. ↗ The routing of the vent lines to protect from the impact of dropped objects. ↗ The location of vent mast away from the accommodation air intakes. ↗ The fixed ammonia gas detection arrangement in the vent mast.	●	●		●	

9. Table H: Ammonia Leak Detection, Management, Isolation and Repair

This section provides the proposed competencies and associated training standards for ammonia leak detection, management, isolation and / or repair on board ships carrying ammonia as fuel. It provides suggestions for new or modified competencies and training above and beyond those needed for other types of leaks that may occur on conventional fuel oil vessels. This section includes:

- General leak characteristics and behaviour
- Sources of leaks
- Detection of ammonia leaks
- Leak management
- Leak isolation
- Leak repair
- Recommissioning.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H1	General	Understanding of the characteristics and behaviour of ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ Ammonia vapour including expansion, cloud formation and dispersion. ↗ Effects of humidity in air or moisture on the density of ammonia. ↗ Changes in the characteristics and behaviour of ammonia vapours when inadvertently mixed with vapours of other substances. ↗ Low-temperature impacts of leaking liquid ammonia. ↗ Measures to prevent rapid vaporisation of leaking liquid ammonia including tarpaulins. ↗ Measures to prevent the rapid vaporisation of liquid ammonia pools including covers.	●	●		●	PA. TM. SP
H2	Potential sources of leaks	Understanding the potential sources of leaks in shipboard ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Understanding the ammonia storage and handling system to identify vulnerabilities that can potentially lead to ammonia leaks. ↗ Corrosion and its impacts, such as the formation of cracks or fractures. ↗ System parameters which if not monitored and managed with acceptable limits can lead to leaks.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H3	Potential sources of leaks	Ability to plan a response to a leak source based on location, severity, likelihood to escalate, potential dispersion, proximity to personnel or vulnerable locations. **Training programme should encompass imparting knowledge on:** ↗ The arrangement of handling and storage systems onboard related to ammonia as a fuel, and familiarity with the operation of the related equipment. ↗ The likelihood of leaks associated with various systems, subsystems, equipment and components, their location and the possible consequences of such leaks. ↗ Leak detection methods for leaks within the annular spaces of double-walled pipes. ↗ Leak detection approach for single walled insulated pipes and double walled insulated pipes. ↗ Communication of leaks that extend beyond the boundaries of the ship.	●	●			PA. TM. SP
H4	Detection of ammonia leaks – fixed detectors	Understanding of the functioning of shipboard fixed ammonia detection and alarm systems. **Training programme should encompass imparting knowledge on:** ↗ The operating principle of fixed ammonia gas detectors, and their functioning and operational limitations. ↗ Interpreting the readings or alarms on the detector to understand the concentration of leak detected and weighting against the threshold levels. ↗ Devices that can assist in analysing the source of ammonia leaks within storage tanks, equipment, piping and piping accessories.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H5	Detection of ammonia leaks – portable detectors	Understanding situations where gas detectors should be used and the functioning of portable/personal ammonia gas detectors. **Training programme should encompass imparting knowledge on:** ↗ When gas detection should be undertaken. ↗ The operating principle of portable/personal ammonia gas detectors, their operation and operational limitations. ↗ The interpretation of the readings on ammonia concentration, and of alarm levels.	●	●	●	●	PA. TM. SP
H6	Detection of ammonia leaks – special equipment and methods	Proficiency in using special equipment and tools to identify the source of ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ Methods for detecting ↗ Principle of operation of specialised equipment capable of identifying sources of ammonia leaks including sonic imagers, thermal cameras, etc. when provided ↗ Methods that assist in pinpointing the source of ammonia leaks including the use of soap-water solution.	●	●			TM. SP
H7	Detection of ammonia leaks – influencing factors on detection	Understanding the factors that can adversely affect the ability of fixed or portable detectors to detect ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ Adverse effect of excessive ventilation of the space being monitored resulting in small ammonia leaks being diluted and may remain undetected. ↗ Adverse effect of atmospheric conditions like wind, rain, fog, etc on the ability of detectors to detect ammonia leaks on open decks and semi-enclosed decks. ↗ Testing and calibration of detectors for repeatability and reproducibility.	●	●		●	TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H8	Detection of ammonia leaks – response	Understanding the shipboard response to be undertaken commensurate with the concentration of leak detected. **Training programme should encompass imparting knowledge on:** ↗ Protocol to be followed in the event of leak detection including PPE usage. ↗ The acute exposure guideline levels (AEGL 1, AEGL2 and AEGL3) threshold levels of ammonia leak. ↗ The response that needs to be undertaken based on the location and concentration such as the threshold limit value (TLV) of the leak detected. ↗ Company procedures regarding ammonia exposure thresholds.	●	●		●	
H9	Detection of ammonia leaks – safety systems	Understanding of shipboard ammonia leak detection and alarm system and interlinked automated safety system responses. **Training programme should encompass imparting knowledge on:** ↗ Location and type of ammonia gas detectors. ↗ Tiers of alarm levels pre-set on the system, and responses to each of the alarm tiers. ↗ Interlinked system automated responses to detection of ammonia including redundancies, interlocks, shutdowns and other designed risk mitigation responses.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H10	Leak management – general	Proficiency in analysing the shipboard arrangements and taking proportionate measures to prevent or minimise the risk to human life, the safety of the ship and the environment. **Training programme should encompass imparting knowledge on:** ↗ The system fail-safe arrangement, redundancies and human interventions in the event of leaks. ↗ Ship-specific contingency plans in the event of leaks. ↗ The strategy with liquid ammonia leaks focused on preventing further vapour generation and maintaining the released ammonia in its safer liquid state, as far as practically possible ↗ Situations where shielding (using tarpaulins, covers, spray shields, containment pipes and hose) may be used to manage vapour releases. This could assist with directing releases to a safer location such as a covered pool, tank, etc. ↗ If allowed and installed, double door air-lock access system for spaces such as FPR and TCS. ↗ Designated safe havens / refuge on board the ship to prevent exposure to persons in the event of a leak. ↗ Emergency escape gear and PPE.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H11	Leak management – ventilation	Understanding the appropriate utilisation of ventilation in toxic spaces or toxic areas onboard in the event of ammonia leak to mitigate the toxicity and flammability risk. **Training programme should encompass imparting knowledge on:** ↗ The distinction between toxic areas located on open decks and toxic spaces within the ship's structural boundaries. ↗ The impact of ventilation on toxicity and flammability. ↗ Dispersion strategies and methods for toxic areas on open decks. ↗ Consequences or risks if ventilation is stopped or fails ↗ Ventilation system on board the ship in spaces containing ammonia handling equipment. ↗ Ventilation system on board the ship in spaces that do not contain ammonia handling equipment but have a possibility of ammonia ingress in the event of a leak. ↗ The strategy to maintain the space with active ammonia leak below the flammability range while measures are taken to eliminate the leak.	●	●		●	
H12	Leak management – system parameters	Understand the actions required for shipboard monitoring and response to the potential of leaks. **Training programme should encompass imparting knowledge on:** ↗ System parameters that are indicative of a prospective leak in the system including alarms. ↗ Monitoring of parameters and alarms determined as critical to leak detection. ↗ Automated response and/or manual intervention to stabilise the system parameters to prevent a prospective leak or to isolate an active leak.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H13	Leak management – atmospheric conditions	Ability to monitor atmospheric conditions including wind direction, humidity, etc to take decisive actions in the event of a leak on deck. **Training programme should encompass imparting knowledge on:** ↗ Interpretation of weather conditions to affect the dispersion of ammonia vapour clouds and mitigate the risk to human life and the safety of the vessel.	●	●		●	TM. SP
H14	Leak management – safe dispersion of leak	Proficiency in determining vapour cloud dispersion within the context of the potential flow rates, leak volumes and the weather / atmospheric conditions. **Training programme should encompass imparting knowledge on:** ↗ Determining the consequence of the leak based on the leak flow rate to take proportionate and determinate actions to minimise the risks. ↗ The effect of atmospheric conditions such as humidity, wind speed and direction, temperature, cloud cover and time of day significantly influence ammonia dispersion. ↗ Vapour cloud dispersion patterns.	●	●		●	TM. SP
H15	Leak isolation – identification of the leak source	Proficiency in analysing the shipboard ammonia system to identify the source of the leak. **Training programme should encompass imparting knowledge on:** ↗ Leak detection equipment including the type of ammonia leak detectors and their limitations. ↗ System parameters and alarms indicative of an ammonia leak, and the source of the leak. ↗ Written procedures outlining or risk assessment addressing measures, to control or limit the leak such as utilisation of tarpaulins and other safe practices.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H16	Leak isolation – system design	Understanding of the design of shipboard ammonia systems related to safe isolation in the event of leaks. **Training programme should encompass imparting knowledge on:** ↗ The design, function and operation of the individual equipment within the integrated ammonia as a fuel system. ↗ System redundancies allowing for safe isolation while maintaining operation at part/full capacity. ↗ Automated responses to breaches in system integrity including leaks. ↗ Manual intervention when required or in the event of an automation failure.	●	●		●	
H17	Repair	Proficiency in analysing the ammonia system to plan steps to eliminate the source of the leak. **Training programme should encompass imparting knowledge on:** ↗ System design to determine the exact location of the leak within the identified area and specifically the equipment or component. ↗ Troubleshooting in identifying the malfunctioning of equipment or failure of components. ↗ System redundancies to isolate part of the system while retaining the operability of the system at rated or reduced capacity. ↗ Rectification of the malfunctions in the system through repairs and/or component replacement. ↗ Safe work practices including risk assessment to determine PPE requirements. ↗ Control, monitoring and inspection requirements for system or equipment isolation prior to invasive repairs. ↗ Use of PPE appropriate to the assessed exposure risk during isolation and first-break.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Comp	Shore
H18	Recommissioning	Proficiency in recommissioning of ammonia systems after repair. **Training programme should encompass imparting knowledge on:** ↗ Specific safety considerations for returning system back to service. ↗ Drying, purging, temperature conditioning and re-pressurisation of the isolated system/equipment. ↗ System pressure/leak testing prior to returning to normal operations. ↗ Parameter monitoring during recommissioning until stable operation. ↗ Use of PPE appropriate to the assessed exposure risk during re-pressuring and recommissioning.	●	●		●	

10. Table I: Ammonia as Fuel: Simultaneous Operations (SIMOPs)

This section provides the proposed competencies and associated training standards for simultaneous operations involving ammonia systems, equipment and components on board ships. It provides suggestions for new or modified competencies and training above and beyond those needed for general or conventional fuel oil related SIMOPs. This section includes:

- Pre-planning
- Hazards
- Operating plan
- Risk assessment
- Management of change
- Impact of zones
- Dropped objects
- Emergency response
- Communications and coordination.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I1	SIMOPs – pre-planning	Ability to conduct preplanning to consider all possible combinations of operations and the implications or restrictions that may change SIMOPs plans due to the presences of ammonia on board. This should include activities such as: ↗ Cargo handling including dangerous cargo. ↗ Passenger and crew embarking/disembarking. ↗ Dangerous goods loading/unloading and of any other goods (such as stores, provisions and waste). ↗ Handling of chemical products and other low flash point products. ↗ Bunkering of fuels other than ammonia and lubricants. ↗ Maintenance, construction, testing and inspection activities ↗ Port and terminal activities. ↗ Unexpected events, such as breakdowns. ↗ Additional risks created by SIMOPS. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties. ↗ Potential ammonia hazards. ↗ Risk assessment. ↗ Gas dispersion models. ↗ Management of change. ↗ SIMOPs plans. ↗ SIMOPs matrices – use and creation. ↗ Emergency response procedures.				●	PA. TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I2	SIMOPs – hazards	Familiarity with new potential hazards that could be occur during SIMOPs activities, how these could be mitigated and / or what response is required (as appropriate to job role). This would include the potential for exposure including toxicity with an ammonia release. **Training programme should encompass imparting knowledge on:** ↗ Risk and hazard awareness. ↗ Emergency response equipment location. ↗ How to use emergency response equipment. ↗ Communications protocols. ↗ Location of safe havens / refuges / escape routes.	●	●	●	●	TM. SP
I3	SIMOPs operating plan	Understanding of SIMOPs Plan, including simultaneous actions matrix, restrictions, and work stoppage criteria. Understanding aspects of the plan that may change to address the presence of ammonia on board as it relates to potential combinations of operations including mooring operations, vessel ballasting, cargo operations, fuel bunkering and /or maintenance. Understanding how plans may change with ammonia onboard with regards to supply and provision operations, relationships with other nearby vessels or terminal operations. Understanding of various roles and responsibilities in the plan and their interfaces with others. **Training programme should encompass imparting knowledge on:** ↗ SIMOPs plan and any necessary adjustments or restrictions due to the carriage of ammonia. ↗ Plans for how ship officers, deck and engine, and corporate personal and various shoreside stakeholders would interact and communicate effectively to manage ammonia related risks.	●	●		●	PA. TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I4	SIMOPs – risk assessment	Proficiency in and understanding of risk assessment and MOC processes to identify vulnerabilities, potential consequences of errors and required safeguards needed during various SIMOPs sequences that could affect ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Risk assessment processes and decision making. ↗ Risk acceptance criteria. ↗ MOC processes and requirements.	●	●	●	●	PA. TM. SP
I8	SIMOPs – management of change	Proficiency with conducting MOC processes and ability to institute any temporary changes with vessels, personnel, systems, or equipment to accommodate SIMOPs. This could include providing emergency response equipment or PPE in a temporary location to facilitate access. **Training programme should encompass imparting knowledge on:** ↗ MOC processes and requirements ↗ Means to obtain temporary or permanent change permissions. ↗ Knowledge of how to cancel or close out a MOC (MOC) permit.	●	●	●	●	PA. TM. SP
I9	SIMOPs – impact on zones	Understanding of the impacts on and modifications needed for safety, toxic, security and marine zones with SIMOPs. Ability to document and communicate anticipated changes, even temporary, to all involved parties including authorities and stakeholders. **Training programme should encompass imparting knowledge on:** ↗ Overall purpose of the controlled / hazardous zones. ↗ Boundaries and conditions around the establishment of zones and process for making modifications. ↗ Roles and responsibilities of companies involved including the person in charge (PIC) for certain operations. ↗ Means for communicating changes to all involved. ↗ Method for communicating problems or issues.	●			●	PA. TM. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I10	SIMOPs – dropped objects	Understanding of the implications of dropped objects, such as during lifting operations, to create a hazardous situation such as a release. (It is assumed the shoreside persons operating lifting appliances or cranes will have required competence, training and certifications as required by the relevant shoreside regulatory body, the port and their company.) **Training programme should encompass imparting knowledge on:** ↗ Familiarity with ammonia potential hazards. ↗ Principles of vapour cloud formation and dispersion. ↗ Industry / company lifting requirements and procedures. ↗ Company emergency response procedures.				●	PA. TM. SP
I11	SIMOPs – emergency response	Understanding of changes to emergency response plans to accommodate SIMOPs. This could include rerouting of personnel, attending vessels / barges or vehicles on the pier. **Training programme should encompass imparting knowledge on:** ↗ Changes to SIMOPs emergency response plans given ammonia is aboard the ship. This could be stricter requirements or additional restrictions.	●	●		●	PA. TM. SP
I12	SIMOPs – emergency response	Familiarity with location of emergency response equipment including temporary locations, safe havens / refuges, how to use equipment including PPE and required emergency response actions to protect oneself in the event of an emergency. Knowledge of management personnel with regards to what information is being given to various personnel. **Training programme should encompass imparting knowledge on:** ↗ Changes or lack of access to emergency response equipment during a particular operation. ↗ MOC processes and requirements.	●	●	●		PA. TM. SP.

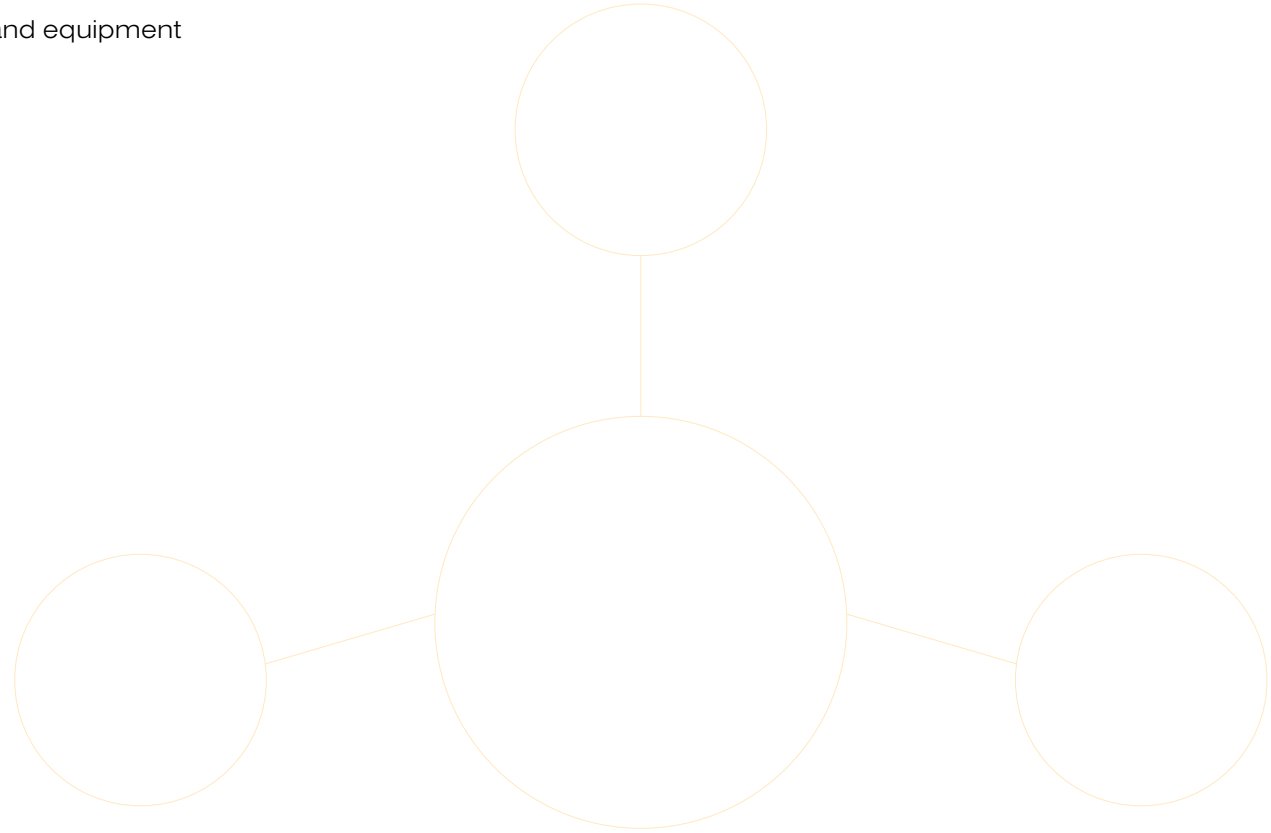
No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I13	SIMOPs – communications	Ability to coordinate with all involved including shipboard personnel and vendors, contractors, and support organisations to accommodate and coordinate SIMOPs activities if different due to ammonia. **Training programme should encompass imparting knowledge on:** ↗ Communication protocols and devices.	●	●			TM. SP.
I14	SIMOPs – communications	Ability to recognise and communicate changes to conditions during SIMOPs activities. **Training programme should encompass imparting knowledge on:** ↗ Ammonia physical and chemical properties. ↗ Ammonia risks and hazards. ↗ Communication protocols and devices.	●	●			TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
I15	SIMOPS – coordination	Ability to coordinate various organisations and various personnel, including specialists such as mooring masters, fuel bunkering personnel, tugs, crane operators, truck / forklift drivers, emergency responders, etc. during SIMOPs. Ability to coordinate with others at the directions of the one person who maintains the overview of all operations. Ability to accommodate changes in personnel based on working hours, watch / shift changes, or fatigue. Understanding of requirements of pre-planning phase requirements for ammonia operations. Familiarity with the decisions on roles and coordination as documented in the SIMOPs plan. Ability to document temporary adjustments in MOC paperwork. **Training programme should encompass imparting knowledge on:** ↗ Pre-planning requirements for in port SIMOPS with ammonia onboard. ↗ Roles and responsibilities of various companies including who has overall responsibility across the various organisations. ↗ Restrictions or limitation due to the presence of ammonia. ↗ Communication / reporting protocols especially if conditions are changing. ↗ MOC processes.	●	●	●		TM. PA. SP.

11. Table J: Ammonia as Fuel: Maintenance

This section provides the proposed competencies and associated training standards for maintenance of ammonia systems, equipment and components on board ships. It provides suggestions for new or modified competencies and training above and beyond those needed for general or in particular, conventional fuel oil system-based, maintenance. This section includes:

- Maintenance of ammonia systems and equipment
- Maintenance of emergency related systems and equipment
- Job safety assessment
- Material compatibility
- Replacement parts / components
- Ammonia related maintenance routines.



No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J1	Maintenance – general	Proficiency in specialised maintenance requirements associated with ammonia systems. This could be related to new systems or equipment such as dual fuel engines / consumers, liquid fuel supply, ammonia release mitigation system (ARMS), boil off gas (BOG) management, vent masts, etc., as applicable. **Training programme should encompass imparting knowledge on:** ↗ Preparation, execution and recommissioning / return to service procedures with due consideration to the hazards with ammonia and ensuring continued reliability of the system.	●	●		●	
J2	Maintenance – ammonia tanks	Understanding of maintenance routines for ammonia tanks. **Training programme should encompass imparting knowledge on:** ↗ Taking tanks out of service –emptying, warming-up, inerting and aeration. ↗ Tank inspection including integrity of internal surface. ↗ Returning tanks to service including drying, inerting, gassing-up, cool-down and filling. ↗ Relief valves (serviced, tested, replaced) and systems.	●	●		●	
J3	Maintenance – piping	Proficiency with ammonia piping maintenance including inspection, installation, repair and replacement. **Training programme should encompass imparting knowledge on:** ↗ Double walled piping with insulation. ↗ Signs of failed insulation/vapour barriers including visible damage, deterioration or corrosion. ↗ Any restrictions such as use of screwed (compression) fittings.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J4	Maintenance – dual fuel engines	Understanding the functionality and operational aspects of dual fuel engines including any special considerations with ammonia. Familiarisation with overall dual fuel operations as appropriate to support roles. **Training programme should encompass imparting knowledge on:** ↗ Design of the fuel supply system to the main / auxiliary engines and other consumers. ↗ Design and functionality of dual fuel engines. ↗ The manufacturer's operations and maintenance manual. ↗ The operation, inspection and maintenance of the specific design of dual fuel engine.	●	●	●	●	
J5	Maintenance – safety systems	Proficiency in specialised maintenance requirements for ammonia related safety systems or components. **Training programme should encompass imparting knowledge on:** ↗ The aspects of maintenance that will be needed for ammonia safety system equipment or devices. ↗ The manufacturer's operations and maintenance manual for the various equipment and components.	●	●			
J6	Maintenance – detectors	Proficiency in testing, calibration and maintenance of ammonia gas detectors – fixed and portable including personal detectors. **Training programme should encompass imparting knowledge on:** ↗ Testing, calibration and maintenance of fixed and portable gas detectors. ↗ Incompatibilities for ammonia gas for sensor probes for other gases (detectors: personal, portable, fixed). This could include any ammonia incompatibilities related to detectors or probes for oxygen, hydrogen sulphide, etc. ↗ Manufacturer's specifications and requirements.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J7	Maintenance – alarm systems	Proficiency with testing and maintenance of ammonia alarms systems including ammonia (visual and audible) alarms. **Training programme should encompass imparting knowledge on:** ↗ Testing and maintenance of alarm systems related to ammonia equipment and spaces.	●	●			
J8	Automated or electronic components	Proficiency in the inspection, testing, calibration and maintenance of automated equipment or components related to ammonia systems including for fuel change overs. Note: There is a prospective increased use of automation. **Training programme should encompass imparting knowledge on:** ↗ Automation system design, layout and logic diagrams. ↗ Functionality of the automation/electronics equipment. ↗ Inspection, testing, calibration and troubleshooting of automated/electronic equipment.	●	●		●	
J9	Maintenance – emergency Shutdowns (ESD)	Proficiency with testing and maintenance of interlocks and emergency shutdown devices (ESD) associated with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Functionality of interlocks and ESDs. ↗ Testing and maintenance of ESDs and interlocks. ↗ Connectivity of ESD signal.	●	●			

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J10	Maintenance – emergency response equipment / PPE	Understanding of special requirements related to ammonia emergency response equipment / PPE inspections. **Training programme should encompass imparting knowledge on:** ↗ New or different equipment or supplies for working with or responding to emergencies involving ammonia. ↗ Protocols for items that are contaminated with ammonia. ↗ Need to ensure protective clothing, chemical or gas tight suits, gloves, etc. are kept completely dry. ↗ For air-purifying respirators, if cartridges are allowed, ensure proper (dry) cartridge is identified for ammonia use, that cartridges are replaced as needed and cartridges to be used are within stated expiration dates. ↗ Inspection protocols for suitability of reusable equipment before and after use. ↗ Decontamination protocols for used items. ↗ As necessary, proper disposal practices.	●	●	●	●	
J11	Job safety assessment –areas with restricted access	Understanding of the requirements for entering and working in restricted areas such as the FPR and TCS for maintenance purposes. **Training programme should encompass imparting knowledge on:** ↗ Interlocks and other safeguards to maintain the integrity of such spaces. If allowed and present, use of air locks. ↗ Location and interpretation of the readings on ammonia detection system. ↗ PPE and other safety equipment required for the maintenance work. ↗ Potential to use remote monitoring of activities via cameras and assigning adequate resources for safety while working in restricted spaces.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J12	Job safety assessment – risks and safety protocols	Understanding of the risks that are intended to be mitigated through the set safety protocols for maintenance work on ammonia systems. Understanding of the safety protocols to be adhered prior to, during and after maintenance work on ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ The reasoning behind the safety protocols, and the outcome they intend to avoid as they related to ammonia. ↗ Safety measures to be taken before commencing maintenance work during progression of work and prior to recommissioning. ↗ Industry best practices towards safe work related to ammonia systems.	●	●		●	
J13	Job safety assessment -procedures and checklists	Knowledge of the procedures and checklists as may be relevant to each maintenance task. **Training programme should encompass imparting knowledge on:** ↗ Company procedures, manufacturer's instructions and industry best practices on maintenance tasks related to ammonia systems.	●	●		●	
J14	Job safety assessment – safe work practices	Understanding of relevant safe work practices with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Risk assessment of maintenance tasks. ↗ Enclosed space entry permits. ↗ Work permits and checklists. ↗ Lock-Out-Tag-Out (LOTO). ↗ Identification of tools, equipment, detectors, supplies need to conduct tasks and respond to potential emergency situations. ↗ Use of specialised equipment such as portable detectors, screens, shields or guards to reduce the potential for exposures.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J15	Job safety assessment -first break /line breaking	Understanding the processes, including risk assessment and job safety / hazard analysis, for the opening of systems, equipment or components where ammonia vapours or liquid could be present. **Training programme should encompass imparting knowledge on:** ↗ The potential for trapped liquids or gas pockets that could remain after the purging. ↗ Company processes related to first break/line breaking including purging and inerting.	●	●		●	
J16	Work scope – industry best practices	Knowledge of best practices adopted within the industry on inspection and maintenance aspects of ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Marine industry best practices on ammonia handling equipment. ↗ Lessons learned from operation of ammonia handling equipment within the maritime industry. ↗ Guidance disseminated from ammonia onshore experience.	●	●	●	●	
J17	Work scope – procedures	Understanding of the procedure and cautions in executing maintenance tasks on ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Safety protocols to be followed for invasive maintenance. ↗ Special skills or techniques for ammonia systems including hot work skills for ammonia compatible materials such as working with aluminium and stainless steel. ↗ Lifting operations associated with maintenance especially near ammonia tanks or deck piping.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J18	Work scope – manufacturer's instruction	Understanding of the manufacturer's instruction manual for executing inspection and maintenance tasks on ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Manufacturer's instructions on safe isolation prior to invasive maintenance. ↗ Special considerations that may be required during disassembly/ assembly of components. ↗ Manufacturer's updates (service letters, etc) derived from in-service learning.	●	●			
J19	Work scope – isolation	Ability to safely isolate equipment in ammonia systems to allow for maintenance tasks and recommission on completion. **Training programme should encompass imparting knowledge on:** ↗ Protocols and procedures for safe isolation of equipment. ↗ Methods for checking and release of trapped vapours or liquids. ↗ Procedures for recommissioning of isolated equipment after maintenance after requisite checks.	●	●		●	
J20	Work scope – cold work	Knowledge of special considerations for working with low-temperature rated components in ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ PPE requirement during the invasive maintenance tasks. ↗ Emergency escape gear for the event of accidental ammonia leak during invasive maintenance.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J21	Material compatibility	Understanding of material compatibility with ammonia storage and handling systems, and associated mountings. Familiarity with material compatibility/incompatibilities as appropriate to support roles. Training programme should encompass imparting knowledge on: **Material incompatibility with ammonia including metals, such as copper, zinc, nickel and their alloys or rubber, certain plastics, polyvinyl chloride, polyesters and viton rubbers, etc.,** ↗ Effects of known incompatible materials on the performance and integrity of ammonia systems. ↗ Stress corrosion cracking and brittle fracture potential.	●	●	●	●	
J22	Replacement in kind or like -for – like	Understanding of inventory management and procurement of specific components associated with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Restrictions regarding using correct replacement components. ↗ Inventory management of components. ↗ Integrity checks on the procurement process, and validation of components received on board.	●	●		●	
J25	Maintenance parts / supply chain	Understanding of the criticality of and specific requirements for procurement of replacement components and other parts of the ammonia system in ensuring the reliability of ammonia handling equipment. **Training programme should encompass imparting knowledge on:** ↗ The importance of meeting replacement components specifications for ammonia service. ↗ Components on ammonia systems identified as required for the safe operation of the ship. ↗ Procurement process of replacement components. ↗ Onboard verification of components.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J26	Invasive maintenance	Understanding of special requirements for invasive maintenance on equipment, pipelines and components of ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Specific training with emphasis on efficiency for maintenance, and appropriate PPE. ↗ Specific training/knowledge provided to seafarers with regards to maintenance regime such as filter changes or cleaning. This could include methods for the use of nitrogen purging and back flushing for ammonia filters.	●	●	●	●	
J28	Isolation of ammonia systems	Understanding of operations to be carried out for safe isolation of part or complete ammonia system. **Training programme should encompass imparting knowledge on:** ↗ Operations such as purging and inerting to render the system safe. ↗ Flushing of equipment prior to invasive maintenance where ammonia vapours could be present. ↗ Handling of inert gas for inerting, and associated hazards. ↗ Hazards associated with trapping of ammonia within an isolated section. ↗ Double block and bleed concept (as per IGF code).	●	●	●	●	
J29	Lubrication oil handling and management	Understanding that ammonia may become entrained in lubrication oil such as in the engine and other equipment. **Training programme should encompass imparting knowledge on:** ↗ The potential of toxic exposure with lube oil contaminated with ammonia. ↗ Precautions to be undertaken when opening crankcase including aeration and gas detection. ↗ Special requirements for lubrication oils to be used in ammonia service, especially with 4-stroke engines. ↗ Oil sampling including scavenge drain oil sampling. ↗ Handling of contaminated waste lube oil.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
J31	Moisture control	Understanding the importance of moisture control related to maintenance tasks especially for return to service. **Training programme should encompass imparting knowledge on:** ↗ The impacts of moisture on anhydrous ammonia. ↗ Procedures related to removing moisture. ↗ Hazards associated with the use of nitrogen.	●	●		●	
J32	Glycol usage	Understanding the maintenance tasks related to glycol in refrigerated systems. **Training programme should encompass imparting knowledge on:** ↗ The maintenance routines related to glycol. ↗ The need to maintaining glycol systems clean. ↗ Potential health hazards associated with glycol as outlined in an SDS.	●	●	●	●	

12. Table K: Ammonia as Fuel: Emergency Response

This section provides the proposed competencies and associated training standards for emergency response related to the ammonia fuel systems, equipment and components used on board ships. It provides suggestions for new or modified competencies and training above and beyond those needed for general or in particular, conventional fuel oil system-based emergencies. This section includes:

- K1: Overall information
- K2: Special hazards
- K3. Emergency response gear
- K4: Coordination and plans
- K5: Safety devices
- K6: Leaks
- K7: Emergency escape devices
- K8: Firefighting
- K9: Muster / evacuation
- K10: Marine incidents.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K1	**Overall Information**						
K1.1	Ammonia release alarms – on board	Familiarity with ammonia leak alarms on board the ship and requisite responses for addressing leaks. **Training programme should encompass imparting knowledge on:** ↗ Identifying and differentiating ammonia release alarms from other alarms on board the ship. ↗ The responses on the ship to safely manage the leak while eliminating the cause. ↗ The responses onshore in preparation for the ammonia leak/ vapour cloud extending beyond the ship's boundaries.	●	●	●	●	PA. TM. SP.
K1.2	Ammonia release alarms – ashore	Familiarity with ammonia leak alarms on shore or port fuelling facilities handling ammonia and for leak response. **Training programme should encompass imparting knowledge on:** ↗ Familiarity with alarm related information in the ship/shore safety checklist. ↗ Identifying and differentiating ammonia release alarms from other alarms at onshore facilities. ↗ The responses on shore to safely manage the leak while eliminating the cause. ↗ The responses on interfacing ship in preparation for the ammonia vapour cloud extending to the ship.	●	●	●		PA. TM. SP.
K1.3	Pre-planning process	Understanding the pre-planning process and the changes in the emergency response plans where actions are coordinated with external parties. **Training programme should encompass imparting knowledge on:** ↗ Knowledge of emergency responses associated with risks of ammonia as fuel on board a ship. This would include toxic zone / areas plans.	●			●	PA. TM. SP..

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K1.4	Pre-planning – ship's role	Understanding the expectations of responses from the ship in the event of an emergency related to ammonia during a ship-shore interface or when located near shoreside populations or other vessels. **Training programme should encompass imparting knowledge on:** ↗ Aspects of expected emergency responses associated with risks with ammonia as a fuel on board a ship.	●	●		●	PA. TM.
K1.5	Pre-planning – shore's role	Understanding the expectations of responses from the shore facilities in the event of an emergency related to ammonia during a ship-shore interface. **Training programme should encompass imparting knowledge on:** ↗ Aspects of expected emergency responses associated with risks with ammonia handling at shore facilities.	●			●	PA. TM.
K1.6	Pre-planning – contractors	Knowledge of contracted entities for emergency response assistance with ammonia, and their role in the event of an emergency. **Training programme should encompass imparting knowledge on:** ↗ The role of contracted emergency response assistance entities, and the boundaries of their intervention in emergency situations. ↗ The contact protocol for the entity in the event of emergency situations.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K1.7	Pre-planning – shipboard firefighting	Understanding of any changes to shipboard firefighting emergency organisation or actions to accommodate presence of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Initial actions and follow up action on detecting, confirming and responding to a fire using pre-planned practice and effective procedures for ammonia-related fires. ↗ Ammonia alarms – including general alarms. ↗ Applicable PPE for firefighting. ↗ Ammonia firefighting plans and strategies.	●	●		●	PA. TM.
K2	**Special Hazards**						
K2.1	Anticipated emergencies – air displacement	Understanding the situation that can arise from ammonia leaks displacing air in enclosed spaces on board. **Training programme should encompass imparting knowledge on:** ↗ Ammonia and gas detection. ↗ The ability of ammonia gas and vapours to displace air in enclosed spaces. ↗ The possibility of cold or moisture-laden ammonia vapours to settle in low spaces. ↗ The potential for atmospheric saturation. ↗ The potential for vacuum conditions.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K2.2	Anticipated emergencies – toxicity	Understanding the situation that can arise from the toxicity of ammonia leaks in enclosed spaces or open areas on board. **Training programme should encompass imparting knowledge on:** ↗ The toxicity aspect of ammonia leaks in enclosed spaces. ↗ The threshold limit value (TLV) on ammonia exposure and AEGL.	●	●		●	
K2.3	Anticipated emergencies – exposure	Understanding the situation where a person is exposed to ammonia, either by dermal / eye contact, respiratory tract or oral ingestion on board. **Training programme should encompass imparting knowledge on:** ↗ How to use information from an SDS. ↗ The actions to be taken in the event of exposure to ammonia based on the form of the ammonia. ↗ The first aid to be administered in the event of dermal / eye, respiratory or oral ingestion.	●	●	●	●	
K2.4	Anticipated emergencies – liquid pools	Understanding the situation that can arise from ammonia liquid pools resulting from leaks including liquids entering the water. **Training programme should encompass imparting knowledge on:** ↗ The characteristics of ammonia liquid pools formed from ammonia leaks. ↗ The measures to control the formation of vapour from leaking liquified ammonia and liquid ammonia pools. ↗ Potential for environmental impacts to marine life.	●	●		●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K2.5	Anticipated emergencies – flammable mixtures	Understanding the situation that can arise from ammonia leaks resulting in flammable mixtures, both in closed and open spaces. **Training programme should encompass imparting knowledge on:** ↗ The flammable range of ammonia in air. ↗ Lower explosive limit (LEL) and upper explosive limit (UEL). ↗ Mixing of ammonia with hydrogen or fuel – the effects on flammability.	●	●		●	PA. TM. SP.
K2.6	Anticipated emergencies – fires	Understanding the situation that can arise from ammonia vapours resulting in an ammonia-based fire. **Training programme should encompass imparting knowledge on:** ↗ The burning characteristics of flames from ammonia-based fires.	●	●		●	PA. TM. SP.
K2.7	Anticipated emergencies – overheating	Understanding the situation that can arise with insulation arrangements not being able to maintain the temperature of liquid ammonia trapped in pipelines and equipment on board. **Training programme should encompass imparting knowledge on:** ↗ Design and arrangement of the piping system including valves and mountings. ↗ The insulation specifications of refrigerated and semi-refrigerated ammonia systems. ↗ Monitoring conditions including temperatures.	●	●		●	
K2.8	Anticipated emergencies – rupture from overpressure	Understanding the situation where the shipboard storage conditions for ammonia can be adversely affected leading to rupture due to overpressure. **Training programme should encompass imparting knowledge on:** ↗ The safe working temperature and pressure range of ammonia in refrigerated, semi-refrigerated and pressurised systems.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K2.9	Anticipated emergencies – vapour clouds from ship	Understanding the situation where the ammonia vapour clouds generated from leaks on board extend beyond the boundaries of the ship in port or anchorages. **Training programme should encompass imparting knowledge on:** ↗ The measures to be taken to prevent or minimise the ammonia vapour clouds extending beyond the boundaries of the ship. ↗ Vapour cloud dispersion characteristics and affecting factors. ↗ The emergency notification protocol for reporting such occurrences to relevant external parties.	●	●		●	PA. TM. SP.
K2.10	Anticipated emergencies – vapour clouds from shore	Understanding the situation where the ammonia vapour clouds generated from leaks on shore enters the boundaries of the ship. **Training programme should encompass imparting knowledge on:** ↗ The measures to be taken to minimise the impact of ammonia vapours on the operation of the ship. This should be addressed in the ship's SMS. ↗ Vapour cloud dispersion characteristics and affecting factors. ↗ Contingency plans aimed towards safety and preventing exposure to persons on board the ship.	●	●		●	PA. TM.
K2.11	Anticipated emergencies – BLEVE	Understanding the situation where the shipboard storage conditions for ammonia can be adversely affected leading to a boiling liquid expanding vapour explosion (BLEVE). **Training programme should encompass imparting knowledge on:** ↗ The conditions that can lead to the phenomenon of boiling liquid expanding vapour explosion (BLEVE), and monitoring of parameters for prevention of its occurrence.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K2.12	Event escalation	Understanding of the operational and environmental factors that can adversely affect and / or escalate an emergency situation related to ammonia **Training programme should encompass imparting knowledge on:** ↗ The effect of essential operations and services contingent to the safety of life, the ship and the environment in dealing with an emergency with ammonia. ↗ This could include operational factors such as ventilation / venting, power, hydraulics, compressed air, heating / cooling capabilities. ↗ Emergency related aspects such as availability of escape routes and safe havens / refuges, fire water, emergency response teams. ↗ The effect of environmental factors, including weather or atmospheric conditions, that can adversely affect an emergency with ammonia. ↗ Gas dispersion characteristics and affecting factors.	●	●		●	PA. TM.
K3	**Emergency response gear**						
K3.1	Emergency response gear for operations and maintenance activities	Knowledge of the emergency response gear required for anticipated emergencies related to ammonia as fuel on board a ship. **Training programme should encompass imparting knowledge on:** ↗ The requirements of PPE and safety gear for each specific emergency scenario anticipated with handling and storage of ammonia as a fuel on board a ship.	●	●	●	●	
K.3.2	Emergency response gear for operations and maintenance activities	Ability to determine locations of emergency response gear and emergency escape aids. **Training programme should encompass imparting knowledge on:** ↗ Location of emergency response gear and emergency escape aids on the ship	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K3.3	Emergency response gear for fuel transfers	Knowledge of the emergency response gear required for anticipated emergencies related to ammonia transfers as fuel to a ship. **Training programme should encompass imparting knowledge on:** ↗ The requirements of PPE and safety gear for each specific emergency scenario anticipated with the transfer of ammonia as fuel to a ship from a barge, terminal, etc.	●	●		●	PA. TM.
K3.4	Emergency response gear for fuel transfers	Familiarity with the shipboard emergency response gear required for anticipated emergencies related to ammonia transfers of fuel to a ship. **Training programme should encompass imparting knowledge on:** ↗ The requirements of emergency response gear and/or PPE for the transfer of ammonia as fuel to a ship.	●	●	●		TM.
K4	**Coordination and plans**						
K4.1	Emergency response coordination	Understand the response coordination with emergency response plans and procedures that accommodate risks associated with ammonia. **Training programme should encompass imparting knowledge on:** ↗ The knowledge of the roles external parties will play in the event of an emergency that escalates to a level where external intervention is required. ↗ Understanding when to involve external organisations. ↗ The ability to understand the internal and external coordination that may be required in the event of an emergency with ammonia as a fuel on board the ship.	●			●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K4.2	Emergency response plans	Familiarity with changes to emergency response plans for anticipated emergencies related to ammonia as fuel on board. **Training programme should encompass imparting knowledge on:** ↗ Actions to be taken in the event of ammonia attaining conditions that fall outside the system-defined safe values. ↗ Ability to respond based on safety zone categorisation. ↗ How to respond in toxic areas or toxic spaces. ↗ Responses in the event of a leak of ammonia into enclosed spaces. ↗ Responses in the event of ammonia leaks forming liquid pools. ↗ Responses in the event of ammonia leaks forming vapour clouds in open and semi-open spaces. ↗ Responses in the event of ammonia leaks resulting in a fire.	●	●	●	●	TM. SP.
K4.3	Emergency response plans	Familiarity with organisational changes to shipboard emergency response plans for anticipated emergencies related to ammonia as fuel on board. **Training programme should encompass imparting knowledge on:** ↗ Organisation of emergency response teams on board, and their roles in the event of an emergency.	●	●		●	
K4.4	Emergency response plans	Understanding of the changes to shipboard emergency response plans for anticipated emergencies related to ammonia as fuel on board. **Training programme should encompass imparting knowledge on:** ↗ Ability to organise and lead in emergency situations with an emphasis on precautions related to toxicity.	●			●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K4.5	Emergency response plans	Awareness of ammonia properties affecting approach to emergency response including rescue, firefighting and first aid on board. **Training programme should encompass imparting knowledge on:** ↗ The physical and chemical properties of ammonia. ↗ The behavioural characteristics of ammonia in different phases. ↗ The toxicity of ammonia, and the smoke related to ammonia fires. ↗ The burning characteristics of ammonia-based fires. ↗ Effect of environmental factors that can escalate the situation.	●	●		●	
K4.6	Emergency response plans – related to ammonia systems	Awareness of emergency situations on board a ship that can adversely affect ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ The emergency situations with other systems that have the potential to develop into an emergency related to ammonia systems.	●	●		●	
K4.7	Changes to emergency response – related to other onboard systems	Awareness of emergency situations with ammonia systems that can adversely affect other systems on board the ship. **Training programme should encompass imparting knowledge on:** ↗ The emergency situations with ammonia systems that can affect other systems on board which are essential to the safety of life, the ship and environmental protection.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K4.8	Changes to emergency response – prevent exposures	Awareness of actions to be taken to prevent exposure to ammonia in the event of ammonia leaks on board. **Training programme should encompass imparting knowledge on:** ↗ The response from persons on board the ship to prevent/ minimise exposure to ammonia leaks. ↗ The location of safe evacuation routes and designated safe havens / refuges on board the ship.	●	●	●	●	
K4.9	Non ammonia event response with ammonia on board	Knowledge with regards to any changes that would be needed to respond to various situations given ammonia is carried on board the vessel. These could include power loss, blackout, loss of propulsion, dropped objects, cargo issues. **Training programme should encompass imparting knowledge on:** ↗ How non-ammonia emergency situations could affect ammonia systems. ↗ Measures to ensure the potential for ammonia systems are secured or protected during such circumstances. How to modify response if ammonia becomes a factor.	●	●		●	
K4.10	Emergency incident commander	Understanding of what new actions may be required by the Emergency Incident Commander to respond to emergencies where ammonia could be a factor either due to its presence or the location of related systems and equipment near the incident location. **Training programme should encompass imparting knowledge on:** ↗ Any new responsibilities or knowledge for the Emergency Incident Commander. ↗ Ammonia hazards. ↗ Plan actions based on ammonia conditions, communicate requirements and direct actions. ↗ Contingency plans.	●			●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K4.11	Deck personnel and vessel repositioning	Deck personnel to understand the potential need to reposition the vessel based on the leak situation, dispersion characteristics and conditions such as sea, weather and atmosphere. Other factors would include the location of other vessels and shoreside establishments. **Training programme should encompass imparting knowledge on:** ↗ Ammonia chemical and physical properties. ↗ Vapour cloud dispersion and factors affecting it. ↗ Potential impacts to personnel on board the vessel or those nearby.	●	●		●	
K4.12	Emergency response training	Knowledge of the anticipated emergency situations related to ammonia as fuel on board. **Training programme should encompass imparting knowledge on:** ↗ The anticipated emergency situations that can arise on board a ship with ammonia as fuel. ↗ The PPE and emergency response gear for each of the individual emergency scenarios.	●	●	●	●	
K4.13	Emergency response training	Understanding of responses required for anticipated emergency situations related to ammonia as fuel on board. **Training programme should encompass imparting knowledge on:** ↗ The appropriate responses in accordance with the emergency. ↗ The organisation and management of emergency response teams.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K4.14	Drills	Ability to incorporate realistic ammonia related scenarios into emergency drill scenarios. **Training programme should encompass imparting knowledge on:** ↗ Chemical and physical properties. ↗ Various types of ammonia related emergencies like fire, leaks, spills and liquid pool formation. ↗ Use of PPE and other emergency related equipment. ↗ Understanding of how non- ammonia emergencies could impact the ammonia systems.	●			●	
K4.15	Coordinated drills	Ability to participate in realistic drills or exercises related to ammonia related emergencies with other organisations. (This is likely to be set up by company management). **Training programme should encompass imparting knowledge on:** ↗ Anticipated ammonia related emergencies. ↗ Understanding of how non- ammonia emergencies could impact the ammonia systems.	●	●	●	●	PA. TM.
K5	**Safety devices**						
K5.1	Safety devices	Familiarity with emergency response related equipment and safety devices on board. **Training programme should encompass imparting knowledge on:** ↗ Updated emergency response actions and roles ↗ Ammonia fire detection ↗ Ammonia and other gas detectors ↗ Water sprays ↗ Drip trays ↗ CCTV monitoring equipment ↗ Firefighting equipment. ↗ Emergency shutdowns.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K5.2	Safety devices	Knowledge of the emergency stops and emergency shut down (ESD) devices on board associated with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Location of emergency stops on the ship, and their operation. ↗ Operation of emergency shut down (ESD) for the engine or ammonia system in the event of an undesired event. ↗ Availability of instructions at the location of operation.	●	●	●	●	
K5.3	Safety devices	Understanding of the functions of the emergency stops and emergency shut down (ESD) devices associated with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Situations that would necessitate the activation of emergency stops and emergency shut down (ESD). ↗ Functioning and effect of emergency stops and emergency shut down (ESD) associated with ammonia systems, and the effect on the overall safe operation of the ship. ↗ Functional differences between ESD levels.	●	●		●	PA. TM.
K5.4	Safety devices	Knowledge of functional testing of safety interlocks, emergency stops and emergency shut down (ESD) devices on board associated with ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Functional testing requirements for safety interlocks, emergency stops and emergency shut down (ESD) devices.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K5.5	Ammonia alarms	Familiarity with ammonia detection alarms on ship especially if there is a “general” ammonia alarm inside the vessel or on deck. **Training programme should encompass imparting knowledge on:** ↗ Correct response upon alarm activation. ↗ Procedures for alarm response. ↗ Potential actions for ensuring safety and reducing the impact of ammonia exposure.	●	●	●	●	
K5.6	Ammonia alarms	Understanding of the required response in the event of ammonia detection alarms based on the seafarer’s shipboard role and location. **Training programme should encompass imparting knowledge on:** ↗ Actions to be taken in the event of ammonia detection alarm for ensuring safety and reducing the impact of ammonia exposure. This may include isolating the ammonia system, wearing emergency escape gear and the use of emergency escape routes or safe havens / refuges.	●	●	●	●	
K6	**Leaks**						
K6.1	Ammonia leaks	Understanding of the hazards associated with ammonia leaks on board the ship. **Training programme should encompass imparting knowledge on:** ↗ The potential safety and health impacts associated with ammonia in enclosed spaces and open environments.	●	●	●	●	TM.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K6.2	Ammonia leaks	Understanding of the responses in the event of detection of ammonia leak on board. **Training programme should encompass imparting knowledge on:** ↗ System design and functionalities to enable eliminating the source of the leak. ↗ Behaviour of ammonia as liquid and a gas to minimise the spread of the leak, and to mitigate the impact on safety, health and environment. ↗ Utilisation of optimal ventilation in enclosed spaces to manage ammonia gas leaks. ↗ Utilisation of tools and aids that minimises the formation of vapour from liquid ammonia leaks. ↗ Selective utilisation of water sprays to mitigate the effects of ammonia leaks.	●	●	●	●	
K6.3	Ammonia leaks	Understanding of the contingency plans for anticipated scenarios of ammonia leaks. **Training programme should encompass imparting knowledge on:** ↗ Contingency plans specific to the anticipated emergency scenarios.	●			●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K6.4	Leaks – water spray	Knowledge of when, where and how to use water spray in areas such as the bunker station and manifold. Ability to give due consideration in decision making to the potential for risks associated with water. For example, water curtains-may be used for reaching lifeboats / totally enclosed motor propelled survival craft (TEMPSC) during abandonment. **Training programme should encompass imparting knowledge on:** ↗ The benefits and hazards associated with the use of water with ammonia. ↗ Potential for forming pools or formation of corrosive ammonium hydroxide solution. ↗ Potential of increased vaporisation of accumulated ammonia liquid pools.	●	●		●	
K6.5	Containment	Understanding of measures and best practices for containment of leaks on board. **Training programme should encompass imparting knowledge on:** ↗ Leak containment measures and best practices. ↗ Liquid pool management. ↗ Best practices and safety measures related to the use of containment aids, and their benefits and drawbacks. ↗ The use of tarpaulins or other suitable aids to contain / control the leakage. ↗ The use of flange guards around equipment in ammonia systems. ↗ Protective sheathing for piping to minimise vaporisation of leaking ammonia.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K6.6	Use of ventilation	Knowledge of the appropriate use of the ship ventilation system to mitigate the risks with ammonia vapours and ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ Knowledge of when, how and length of time needed to ventilate. ↗ System design, operation and restrictions for the ventilation system.	●	●		●	
K6.7	Ammonia leaks	Ability to respond to ammonia ingress into spaces on board that do not contain ammonia systems. **Training programme should encompass imparting knowledge on:** ↗ Location and use of emergency escape equipment. ↗ Actions to be taken with ventilation measures to minimise the impact of the ingress.	●	●		●	
K6.8	Ammonia leaks	Ability to respond to ammonia ingress into facilities on shore due to ammonia leaks from the ship or due to leaks within the shore facility. **Training programme should encompass imparting knowledge on:** ↗ Location and use of emergency escape equipment. ↗ Actions to be taken with ventilation measures to minimise the impact of the ingress.					TM. PA.
K6.9	Ammonia leaks	Understanding of the interaction of ammonia leaks with other substances on board that can result in an escalation of the emergency situation. **Training programme should encompass imparting knowledge on:** ↗ The formation of corrosive solution of ammonium hydroxide when water is mixed with ammonia. ↗ Understanding that the addition of water to ammonia liquid pools causes an exothermic reaction resulting in heat and increased vaporisation.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K6.10	Safety zones	Knowledge of safety zones and the precautions and requirements within these designated areas. **Training programme should encompass imparting knowledge on:** ↗ Designated safety zones on the ship and requirements set out within each category of safety zone. ↗ Obtaining information from shoreside concerning the establishment of safety zones.	●	●	●	●	PA. TM. SP.
K6.11	Disposal of ammonia residues	Understanding of the protocol for collection, storage and management of ammonia waste and ammonia contaminated water, oil, equipment, etc. **Training programme should encompass imparting knowledge on:** ↗ Residual and contaminated waste management plans. ↗ Means for offloading of wastes including necessary vendor arrangements and recordkeeping.	●	●	●	●	SP.
K6.12	Spills to water and land	Understanding of the potential impact of ammonia entrained in water spilling into local waters or the sea and the potential impact on marine life. **Training programme should encompass imparting knowledge on:** ↗ Potential impact of pollution of water bodies with liquid ammonia or ammonia in water. ↗ Changes to reporting and response protocols.	●	●		●	PA. TM.
K6.13	Spills to water and land	Understanding the impacts of surface pollution directly from ammonia leaks or water contaminated with ammonia. **Training programme should encompass imparting knowledge on:** ↗ Potential impact of pollution of water bodies with liquid ammonia or ammonia in water. ↗ Changes to reporting and response protocols.	●	●		●	PA. TM.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K6.14	Spills to water and land	Understanding the toxicity, corrosivity, reactivity, and environmental impact of ammonia leaks and ammonia-contaminated waste on water bodies and land. **Training programme should encompass imparting knowledge on:** ↗ The environmental impact potential of ammonia on water and on land.	●	●	●	●	PA. TM.
K6.15	Spills to water and land	Understanding of the procedures for handling of transfers of contaminated ammonia wastes from the ship, and its subsequent management. **Training programme should encompass imparting knowledge on:** ↗ The safe handling of ammonia transfers to the ship, and of ammonia residues to the shore reception facility. ↗ The retention of records of transfers related to ammonia and ammonia residues. ↗ Company waste management plan and procedures.	●	●		●	PA. TM. SP.
K6.16	Spills to water and land	Understanding of measures to be taken to minimise the impact of a spill from a safety and environmental perspective. **Training programme should encompass imparting knowledge on:** ↗ Shipboard pollution prevention plan including additions relevant to ammonia spills. ↗ Spill response protocols and procedures relative to ammonia spills in water and on land.	●				PA. TM.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K7	**Emergency Escape Devices**						
K7.1	Emergency escape devices on board	Familiarity with the location of emergency escape devices and PPE onboard. **Training programme should encompass imparting knowledge on:** ↗ Emergency escape devices and PPE to protect against ammonia exposure in an emergency. ↗ Location of such devices on board the ship. ↗ Process or requirements for orienting visitors (e.g., day visitors, contractors, ship suppliers, company personnel, etc.) onboard the vessel with the location of emergency escape devices.	●	●	●	●	
K7.2	Emergency escape devices on board	Familiarity with the donning of the emergency escape devices on board and understanding of the endurance characteristics of the devices. **Training programme should encompass imparting knowledge on:** ↗ Donning and removal of the emergency escape devices and PPE. ↗ Decontamination procedures after use, if appropriate. ↗ Criteria for use in ammonia-laden environments including maximum time duration and concentration. ↗ Process or requirements for orienting anyone visiting (e.g., day visitors) or conducting business (e.g., contractors, ship suppliers, etc.) onboard the vessel with the use of emergency escape devices.	●	●	●	●	
K7.3	Emergency escape devices on shore	Familiarity with the location of emergency PPE onshore suitable for ammonia. **Training programme should encompass imparting knowledge on:** ↗ PPE for escape from ammonia leaks on shore in an emergency. ↗ Location of such devices on the shore facility.					TM. PA. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K7.4	Emergency escape devices on shore	Familiarity with the donning of the emergency escape devices and understanding of the endurance characteristics of the devices. **Training programme should encompass imparting knowledge on:** ↗ Donning and removal of the emergency escape devices. ↗ Decontamination procedures after use for reusable equipment / devices. ↗ Criteria for use in ammonia-laden environments including maximum time duration and concentration as defined by the manufacturer.					TM. PA. SP

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8	**Fire fighting**						
K8.1	Firefighting strategy	Understanding of the firefighting agents and methods to use to control and extinguish fires including ammonia-related fires. This understanding should be aimed at the level appropriate to the role of the individual. **Training programme should encompass imparting knowledge on:** ↗ Differences in firefighting approaches for various ammonia-based fires. ↗ Differences in firefighting approaches for fires on board that include ammonia burning along with other fuels and materials. ↗ Proficiency with the use of applicable firefighting appliances including any unique equipment for ammonia-related fires. ↗ The effects of the use of water as firefighting medium on ammonia-based fires where potentially ammonia liquid pools are formed. ↗ The optimal use of ventilation for the dispersion of ammonia vapours and smoke from the space during firefighting. ↗ The fact that common agents do not have the desired effect and efficacy on ammonia fire. This includes commonly installed fixed firefighting media including CO_2, dry chemical powder and aqueous film forming foam (AFFF). ↗ Knowledge of how firefighting approach may differ for various fires if ammonia is involved including the approach for other fuels or chemicals.	●	●	●	●	TM. PA.
K8.2	Unique impacts of ammonia fires	Understanding of potential unique impacts of the presence of ammonia during fires including the potential for rapid expansion, vapor cloud formation and oxygen displacement. **Training programme should encompass imparting knowledge on:** ↗ The flammable range of ammonia in air. ↗ Lower explosive limit (LEL) and upper explosive limit (UEL). ↗ The flame burning characteristics of ammonia-based fires. ↗ The formation of toxic smoke.	●	●		●	TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.3	Location of fire – on deck	Understanding the factors that can affect the ability to fight ammonia-based fires on open decks on board. **Training programme should encompass imparting knowledge on:** ↗ The factors that can adversely affect the ability to fight fires. ↗ Weather and atmospheric conditions. ↗ Principles of vapourisation, cloud formation and cloud dispersion. ↗ Flammable limits. ↗ Presence of flammable materials. ↗ Sources of ignition	●	●		●	
K8.4	Location of fire – on deck	Ability to mitigate the effect of atmospheric and operational factors on vaporisation and vapour cloud dispersion. **Training programme should encompass imparting knowledge on:** ↗ The measures to mitigate the effect of atmospheric and operational factors that increase vaporisation and impede effective vapour cloud dispersion such as water spray.	●	●			
K8.5	Location of fire – on deck	Understanding of the occupational health and environmental impact of the release of ammonia vapour and combustion residue in air during the fire. **Training programme should encompass imparting knowledge on:** ↗ Health hazards, including toxicity. ↗ Environmental impacts.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.6	Location of fire – impacting others	Understanding of the effects and impacts of the fire on the surrounding assets, in anchorages and ports. This could be related to a Type C deck mounted tank or other ammonia related equipment on deck. **Training programme should encompass imparting knowledge on:** ↗ The effects and impacts of smoke from ammonia-based fires. ↗ Contingency planning with ports to identify areas of concern. ↗ Vapour cloud formation and dispersion characteristics.	●	●		●	
K8.8	Location of fire – on deck with type C deck mounted tank	Understanding the factors that can adversely impact the effective extinguishment of fires on ammonia storage tanks located on open decks. **Training programme should encompass imparting knowledge on:** ↗ The measures and strategies for fighting fires on Type C deck mounted storage tanks. ↗ The impact of atmospheric conditions in fighting fires for Type C deck mounted tanks stored on open decks.	●	●		●	
K8.9	Potential for BLEVE	Understanding of the potential of BLEVE in ammonia storage tanks, its effect on the ship assets and the overall safety of the ship. **Training programme should encompass imparting knowledge on:** ↗ The conditions that can lead to the occurrence of BLEVE. ↗ The effect on the surrounding equipment and operations essential for the safe operation of the ship.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.10	Potential for BLEVE	Understanding of the potential of BLEVE in ammonia storage tanks and its impacts on the surrounding assets, in anchorages and ports. **Training programme should encompass imparting knowledge on:** ↗ The conditions that can lead to the occurrence of BLEVE. ↗ The effect on the surrounding equipment and operations essential for the safety of the shore assets.	●	●		●	PA. TM.
K8.11	Location of fire – enclosed space – FPR, TCS	Understanding the explosion phenomena of deflagration and detonation with ammonia vapours catching on fire. **Training programme should encompass imparting knowledge on:** ↗ The explosion mechanisms of detonation and deflagration.	●	●		●	TM.
K8.12	Location of fire – enclosed space – FPR, TCS	Understanding the measures to be undertaken to prevent or mitigate the factors that can lead to explosions. **Training programme should encompass imparting knowledge on:** ↗ Ammonia's physical and chemical properties. ↗ Explosive limits. ↗ Ventilation system design.	●	●		●	
K8.13	Location of fire – enclosed space – FPR, TCS	Understanding the ventilation strategy within enclosed spaces to mitigate the formation of flammable atmospheres and evacuating toxic smoke from fires. **Training programme should encompass imparting knowledge on:** ↗ Ammonia's physical and chemical properties. ↗ Flammable and explosive limits. ↗ Ventilation system design.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.14	Location – engine room	Understanding of the occupational health and environmental impact of release of ammonia vapour and combustion residue during the fire. **Training programme should encompass imparting knowledge on:** ↗ Health hazards, including toxicity. ↗ Environmental impacts such as those associated with residues, debris or waste. ↗ PPE and emergency response gear requirements.	●			●	TM.
K8.15	Location – engine room – debris from fire	Understanding the impacts associated with remaining residues and wastes. **Training programme should encompass imparting knowledge on:** ↗ Health hazards, including toxicity. ↗ Environmental impacts such as those associated with residues, debris or waste. ↗ PPE and emergency response gear requirements.	●	●	●	●	
K8.16	Location – engine room – ventilation	Understanding of the changes in ventilation strategy that need to be followed in the event of ammonia-involved fire in the engine room. **Training programme should encompass imparting knowledge on:** ↗ Ventilation system principles/design. ↗ The ammonia vapour characteristics in air – lighter than air. ↗ Ammonia vapours that are cold or laden with moisture can be heavier and tend to accumulate in lower areas of enclosed spaces.	●	●		●	
K8.17	Location – engine room – other materials	Understanding of the change in strategy if an ammonia-based fire spreads to other combustible material in the engine room. **Training programme should encompass imparting knowledge on:** ↗ Potential changes in the characteristics of the flame of the fire. ↗ Potential changes to the firefighting strategy.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.18	Planning for fire response	Ability to understand the fire safety plans with emphasis on the threats and potential sources of flammables that relate to the ammonia fuel system. **Training programme should encompass imparting knowledge on:** ↗ Onboard fire plan and its locations. ↗ Location of ammonia storage tanks and ammonia handling equipment.	●	●			
K8.19	Preparation for firefighting – at sea	Understanding of the behaviour of ammonia-based fires in enclosed spaces and open decks. **Training programme should encompass imparting knowledge on:** ↗ Physical, chemical and dispersion characteristics. ↗ The influence of vapour concentrations in enclosed spaces. ↗ Flammability and explosive limits.	●	●		●	
K8.20	Preparation for firefighting – at sea	Knowledge of the measures to prevent or minimise the spread of ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ Physical, chemical and dispersion characteristics. ↗ Location and functionalities of fire doors, funnel flaps and fire dampers. ↗ Ventilation system design.	●	●		●	
K8.21	Preparation for firefighting – at sea	Knowledge of the toxicity in the smoke with ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ The safety measures to be followed to prevent exposure to smoke resulting from ammonia-based fires.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.22	Preparation for firefighting – at sea	Proficiency with using fixed firefighting appliances appropriate for ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ Firefighting appliances on board the ship, and their selective use with ammonia-based fires.	●	●	●		
K8.23	Preparation for Firefighting –at sea	Knowledge of the location of ammonia related emergency stops for equipment and emergency shutdown switches for the system. **Training programme should encompass imparting knowledge on:** ↗ The location of emergency stop switches. ↗ The function of each emergency stop. ↗ Location and function of ESDs for the system.	●	●	●	●	
K8.24	Preparation for firefighting –-at sea	Knowledge of the location of operating ventilation flaps and dampers – both local and remote operating locations in the ammonia system. **Training programme should encompass imparting knowledge on:** ↗ The location of manual and remote operation of ventilation flaps/dampers related to the ammonia system.	●	●	●	●	
K8.25	Preparation for firefighting – at sea	Ability to make decisions on activating ammonia related emergency stops, and ventilation flaps and dampers taking into consideration the overall effect of the actions and the potential impacts of ammonia on the ship's safety. **Training programme should encompass imparting knowledge on:** ↗ The actions that have to precede or follow the activation of emergency stops and/or ventilation flaps/dampers. ↗ The operations impacted by the activation of specific emergency stops. ↗ The effect of closing ventilation flaps/dampers on persons and equipment in the space.	●				

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.26	Preparation for firefighting – at sea	Ability to assess the situation in deciding on the strategy to minimise the spread of the fire in or near ammonia systems/ equipment. **Training programme should encompass imparting knowledge on:** ↗ Scenario assessment of developing ammonia-based fires in strategising the best possible approach to control the fire.	●				
K8.27	Preparation for firefighting – at sea	Ability to guide the firefighting team to respond to the ammonia-based fire with minimal risk to life, property and environment. **Training programme should encompass imparting knowledge on:** ↗ Scenario assessment of developing ammonia-based fires in strategising the best possible approach to control the fire with minimal risk to life, property and environment.	●	●			
K8.28	Preparation for firefighting – shipboard fire in the port	Ability to communicate and coordinate the ammonia firefighting efforts with external parties. **Training programme should encompass imparting knowledge on:** ↗ Approach to ammonia firefighting with local organisations.	●				
K8.29	Preparation for firefighting – shipboard fire ~~at~~ while moored	Ability to intervene and render assistance to a moored ship in fighting ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ Scenario assessment of fire on board ship at a pier. ↗ Coordination between the emergency response organisation on board the ship.				●	PA. TM. SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.30	Emergency response roles	Understanding of the organisation of emergency response teams on board ships. **Training programme should encompass imparting knowledge on:** ↗ The organisation of emergency response teams with scenarios related to ammonia-based fires and ammonia leaks.	●	●	●	●	PA. TM.
K8.31	Firefighting response roles	Understanding of onboard fire response roles and any changes to roles to accommodate the presence of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Changes to emergency response including command and control strategy, firefighting roles or emergency gear given the presence of ammonia. ↗ Detailed understanding of changes to emergency response gear or any required PPE for various situations.	●	●		●	
K8.32	Accumulations from firefighting – on deck	Understanding that firefighting (and ammonia involved fire) with water can form liquid pools at the firefighting location which could result in ammonia contaminated pools and spills. **Training programme should encompass imparting knowledge on:** ↗ Characteristics of liquid ammonia pools. ↗ Any mitigation measures for the pools such as tarps or covers. ↗ Strategy for addressing water accumulation and preventing / mitigating spills. ↗ Principles of vapour dispersion characteristics.	●	●	●	●	TM.
K8.33	Spill containment from firefighting – on deck	Understanding that ammonia liquid pools will vaporise at ambient temperature, and measures to minimise the rate of vaporisation. **Training programme should encompass imparting knowledge on:** ↗ Best practices to minimise the vaporisation of liquid ammonia pools including best practices covers and tarpaulins.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.34	Spill containment from firefighting – on deck	Understanding of the possibility of runoff water from firefighting operations mixing with spilled ammonia to form a toxic and corrosive alkaline solution. **Training programme should encompass imparting knowledge on:** ↗ The reaction of water with ammonia resulting in the formation of corrosive ammonium hydroxide (NH4OH) solution. ↗ Safe collection, handling and storage of ammonia wastewater and residues to prevent potential water and/or land pollution, as practicable.	●	●		●	
K8.35	Spill containment from firefighting – inside ship	Understanding the effect of ingress of water contaminated with ammonia in equipment and associated mountings including electrical cables, and the measures to ensure and restore their integrity. **Training programme should encompass imparting knowledge on:** ↗ The reactivity of water contaminated with ammonia on equipment and associated mountings. ↗ Post-exposure checks and testing in making a decision to treat or replace. ↗ The measures to be taken to decontaminate components appropriately where deemed satisfactory for continued use. ↗ The requirement to replace the exposed components where irreversible harm has been caused to the integrity of the equipment.	●	●		●	
K8.36	First aid	Understanding of the first aid that will need to be administered in anticipated scenarios of injury and exposure when handling ammonia-based fires. **Training programme should encompass imparting knowledge on:** ↗ Special first aid requirements for ammonia exposures or injuries during firefighting. ↗ Information of location of first aid instructions and materials.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K8.37	First aid	Understanding of immediate first aid measures that will need to be administered in anticipated scenarios of injury and exposure when handling ammonia leaks and spills. **Training programme should encompass imparting knowledge on:** ↗ Special first aid requirements for ammonia exposures or injuries from ammonia leaks. ↗ Information of location of first aid instructions.			●		
K8.38	Decontamination	Understanding of post-emergency response decontamination measures for PPE, emergency response gear, equipment and tools used during ammonia emergency response. **Training programme should encompass imparting knowledge on:** ↗ Written processes for treating potential ammonia contaminated items including initial steps to prevent exposures to personnel.	●	●	●	●	
K8.39	Waste management	Understanding of post-event residue and waste management processes. **Training programme should encompass imparting knowledge on:** ↗ Means for collection and disposal of post-emergency event residues and wastes including precautions for handling these.	●	●		●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K9	**Muster / evacuation**						
K9.1	Muster / evacuation	Understanding of the principles of emergency evacuation and the changes that may be required with ammonia on board. **Training programme should encompass imparting knowledge on:** ↗ Checks for the presence of ammonia. ↗ PPE requirements. ↗ Locations for sheltering such as safe havens, refuges or mustering points. ↗ Routes for escape. ↗ Type of lifeboat / TEMPSC if changed to accommodate ammonia onboard. ↗ Use of water spray to access lifeboats / TEMPSC.	●	●	●	●	
K9.2	Muster / evacuation	Understanding of factors that could impact muster or evacuation. **Training programme should encompass imparting knowledge on:** ↗ Ammonia detection, weather conditions, sea conditions, atmospheric conditions, and damage impacts from events.	●			●	
K9.3	Muster / evacuation	Knowledge of conditions or situations that would impact the ability to seek and use safe havens / refuges or to muster. **Training programme should encompass imparting knowledge on:** ↗ The potential situations or factors that will render the muster points or safe havens / refuges not suited for the intended purpose. ↗ Situations that could affect safe escape / evacuation routes.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K9.4	Muster / evacuation	Understanding of the communication protocols for announcing the need to seek safe havens / refuges, muster or evacuate due to ammonia related emergency. **Training programme should encompass imparting knowledge on:** ↗ Communication protocols onboard the ship relevant to emergency muster and evacuation.	●	●	●	●	
K9.5	Muster / evacuation	Understanding the procedure for safe isolation of ammonia system in the event of ship abandonment (without ammonia leak detection). **Training programme should encompass imparting knowledge on:** ↗ Company emergency response procedures for abandonment. This would include measures needed to confirm / verify on board systems including ammonia are secured before leaving.	●			●	
K9.6	Muster / evacuation	Understanding any requirements for abandonment in the event of a major ammonia leak detection including PPE, use of water spray, etc. **Training programme should encompass imparting knowledge on:** ↗ Company emergency response procedures for abandonment. ↗ Measures to secure on board systems including ammonia before leaving.	●	●	●	●	

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K10	**Marine incidents**						
K10.1	Allision / collision /grounding	Understanding how navigational impacts of carrying ammonia if there is a collision or grounding. **Training programme should encompass imparting knowledge on:** ↗ Training on leak detection and on handling large heel/trim angles, due to allision, collision and grounding especially where there are areas such as certain tanks where gas pockets could form. ↗ Communications with other organisations such as other vessels with regards to the carriage of ammonia on board the ship.	●	●		●	SP.
K10.2	Allision / collision / grounding	Understanding that following an allision, collision or grounding, there is a need to perform additional checks for leakages including in areas not necessarily considered hazardous areas (pipe work, void spaces, etc.). **Training programme should encompass imparting knowledge on:** ↗ Physical and chemical properties of ammonia. ↗ General arrangement (GA) plans of the ship. ↗ Location of spaces containing ammonia storage tanks, equipment and pipelines, and spaces that are contiguous to such spaces.	●	●		●	SP.
K10.3	Damage stability	Ability to determine potential risks to loss of containment of ammonia in the event of damage to the ship. **Training programme should encompass imparting knowledge on:** ↗ Ammonia system storage tank and handling equipment location and design.	●	●		●	SP.

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K10.4	Damage stability	Proficiency in the assessment of damage stability and ability to determine potential risks to containment of ammonia. **Training programme should encompass imparting knowledge on:** ↗ Damage stability calculations of potential scenarios. ↗ Contingency plans. ↗ Communication of the situation with emergency shore response entities.	●			●	
K10.5	Security plans	Understanding of changes for responding to security events such as terrorism, social/political unrest, and political events given ammonia is carried on board the vessel. Familiarity with changes to established response plans. **Training programme should encompass imparting knowledge on:** ↗ Changes to security plans for ammonia-fuelled vessels. All involved to have training to remain safe under various conditions while addressing threat.	●				PA. TM.
K10.6	Onboard marine incidents	Ability to recognise and respond to marine hazards with due consideration to the location of ammonia equipment / tanks and potential presence of ammonia in local area that was impacted. **Training programme should encompass imparting knowledge on:** ↗ Company emergency response procedures. ↗ Ship mooring safety procedures. ↗ Snapback zones. ↗ Safe handling of overhead loads. ↗ Loss of anchor. ↗ Maintenance activities including hot work. ↗ Cargo-related incidents (leaks, fires, explosions).	●	●			TM

No	Topic	Competency & Training standard	SMT	SJO	SSR	Corp	Shore
K10.7	External emergency response entities	Understanding of the general ship's structure, equipment and safety arrangement on board, and knowledge of dealing with hazards associated with ammonia as a fuel by entities such as emergency response contractors. **Training programme should encompass imparting knowledge on:** ↗ General arrangement (GA) plans. ↗ Fire plans. ↗ Stability calculations. ↗ Ammonia hazards including toxicity, flammability and explosivity or other hazards unique to the carriage of ammonia. ↗ Ammonia-based fire burning characteristics. ↗ Damage stability plans and any modifications for carriage of ammonia.				●	PA. TM. SP.

13. Conclusions

As a follow-up to Human Factors Considerations work previously undertaken by the MMMCZCS and The Decarb Hub, the Ammonia Phase 3 Competencies and Training project was created. Under this work scope, a framework outlining minimum competency and training standards similar to those commonly documented in the International Maritime Organization's (IMO) International Convention on Standards of Training, Competency and Watchkeeping for Seafarers Code (STCW) was created. The results of that task are published in a separate report.

For the second stream of project work, which this report documents, it was decided that it would be beneficial to conduct a more in-depth analysis of operations, maintenance and emergency response tasks. This analysis provides detailed competency requirements and training standards for those specific tasks beyond what is outlined in a typical STCW framework.

To set the stage for the detailed work, those topics that were common to most tasks were evaluated and then selected scenarios were chosen for further review. As a result, the deliverables under this report were grouped as follows:

Operational Scenario Commonalities

- **A.** Hazards, Characteristics and Hazards Awareness
- **B.** Overall safety & Environmental / Risk Awareness
- **C.** Occupational Health & Safety
- **D.** Operational / Process Safety
- **E.** Regulations, Local requirements, Industry guidelines

Selective Operational, Maintenance and Emergency Response Evaluations

- **F.** Fuel Storage, Management and Transfers
- **G.** Ammonia Gas Purging and Venting from Compartments
- **H.** Ammonia Leak Detection, Management, Isolation and Venting
- **I.** Simultaneous Operations (SIMOPs)
- **J.** Maintenance
- **K.** Emergency Response

For the various scenarios, information was provided to suggest what competencies would be beneficial to seafarers based on their shipboard role. Where shoreside personnel would need certain knowledge, understanding or proficiencies to work with ship-based personnel, the related competencies and training standards were identified.

It is believed that the information provided in this report would be useful to marine operations and training departments within companies choosing to operate ammonia fuelled vessels. It is also believed the information could be informative to others with an interest in ammonia fuel such as regulators, flag States, port States, non-governmental agencies and training institutions

The detailed operations and maintenance evaluations in this report, combined with the previously published framework, should provide an excellent starting point for interested parties to identify the future requirements for augmenting seafarers previous training for and experience with conventional fuel oil to be able to take a safe and environmentally friendly approach to dual fuel operations unitising ammonia fuel.

With that said, it must also be remembered that competencies and training are one aspect of human factors considerations that will need to be considered by industry when moving to the use of ammonia as a fuel. It is hoped that the information provided on this topic, will be helpful for highlighting the need for due consideration of supporting the seafarers in the conduct of tasks. It is also believed that the information in this report can facilitate companies with the following:

- Creating human centric designs of systems, equipment and interfaces
- Crafting supportive written procedures, processes and practices
- Assessing workload distribution given additional systems / hardware, interfaces and tasks
- Identifying any new roles and responsibilities for seafarers or shoreside counterparts
- Highlighting the role of process safety and the management of process hazards in addition to those associated with traditional occupational health and safety
- Encouraging a formal method for managing change when moving from conventional fuel oil to the addition of ammonia as a second fuel

Many of these factors and their impacts are introduced in the Human Factors Considerations: Ammonia Fuel End-of-Stage Report published by the Decarb Hub and Mærsk Mc-Kinney Møller's Center for Zero Carbon Shipping in 2023.

Finally, it should be also noted that this report reflects the state of the planned technology, known fuel characteristics and industry experts' opinions that existed at the time of publication. With changes to regulations, advances in ship design, including system and engine technologies, the proposed competencies and training standards outlined here would need to be re-examined in light of such changes. In addition, the marine industry and its regulators may form different views on the requirements for staffing ships and the training standards for seafarers than those provided here.

Appendix 1: List of abbreviations

Abbreviation	Description
AEGL	Acute Exposure Guideline Level
ARMS	Ammonia Release Mitigation System
AFFF	Aqueous Film Forming Foam
BLEVE	Boiling Liquid Expanding Vapour Explosion
BOG	Boil Off Gas
CFO	Conventional Fuel Oil
CO_2	Carbon Dioxide
ECR	Engine Control Room
EEBD	Emergency Escape Breathing Devices
ESD	Emergency Shut Down
FPR	Fuel Preparation Room
GA	General Arrangement
GCMD	Global Centre for Maritime Decarbonisation
GCU	Gas Combustion Unit
IAPH	International Association of Ports and Harbours
IBC	International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
IEC	International Electrotechnical Commission
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IGF	International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organization

Abbreviation	Description
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISM	International Safety Management Code
ISO	International Organisation for Standardisation
JHA	Job Hazards Analysis
JSA	Job Safety Analysis
Kg / m^3	Kilogram per cubic meter (density)
KUP	Knowledge, Understanding, and Proficiency
LEL	Lower Explosive Limit
LFL	Lower Flammability Limit
LNG	Liquified Natural Gas
LOTO	Lock Out Tag Out
LPG	Liquefied Petroleum Gas
LR	Lloyd's Register
MARPOL	International Convention for the Prevention of Pollution from Ships
MeOH	Methanol
The Decarb Hub	The Lloyd's Register Maritime Decarbonisation Hub
MFAG	Medical First Aid Guide for Use in Accidents involving Dangerous Goods
MJTTF	Maritime Just Transition Taskforce
MMMCZCS	Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
MOC	Management of Change
n/a	Not Applicable
N_2	Nitrogen
NH_3	Ammonia
NH_3OH	Ammonia Hydroxide

Abbreviation	Description
N_2O	Nitrous Oxide
NOx	Nitrogen Oxide
O_2	Oxygen
OBQ	On Board Quantity
OCIMF	Oil Companies International Marine Forum
OEM	Original Equipment Maker
PA	Port Authority
PEL	Permissible Exposure Limit
PIC	Person in Charge
PPM	Parts Per Million
PPE	Personal Protective Equipment
PRV	Pressure Relief Valve
PTW	Permit to Work
REL	Recommended Airbourne Exposure Limit
ROB	Remain On Board
SCBA	Self-Contained Breathing Apparatus
SCR	Selective Catalytic Reduction
SDS	Safety Data Sheet
SGMF	Society for Gas as a Marine Fuel
SIGTTO	Society of International Gas Tanker and Terminal Operators
SIMOPS	Simultaneous Operations
SJO	Shipboard Junior Officer
SME	Subject Matter Expert
SMS	Safety Management System

Abbreviation	Description
SMT	Shipboard Management Team
SP	Shore Support Personnel
SSR	Shipboard Support Ratings
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TCS	Tank Connection Space
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
TLV	Threshold Limit Value
TLV-C	Threshold Limit Value – Ceiling Concentration
TLV-STEL	Threshold Limit Value – Short Term Exposure Limit
TLV-TWA	Threshold Limit Value – Time Weighted Average
TM	Terminal Management
UEL	Upper Explosive Limit
UFL	Upper Flammability Limit

Appendix 2: Definition of Terms

Term / Abbreviation	Description	Source
Acute Exposure Level Guidelines – AEGL	Guidance in dealing with rare, usually accidental, releases of chemicals into the air. AEGLs are expressed as specific concentrations of airborne chemicals at which health effects may occur. AEGLs are calculated for relatively short exposure periods – e.g., 10 minutes to 8 hours. AEGL "levels" are dictated by the severity of the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe. All levels are expressed as parts per million or milligrams per cubic meter (ppm or mg/m^3) of a substance above which it is predicted that the general population could experience, including susceptible individuals:	US EPA
Air Lock	An enclosed space for entrance between a gas dangerous zone and a gas safe space.	Adapted from Wartsila
Ammonia alarm	The audible and visual notification of the potential presence of ammonia in the atmosphere in a shipboard area. This alarm is in addition to those alarms associated with computer systems, local panels, hardwired control boards. This would be like a Carbon Dioxide (CO_2) alarm used in an engine room space.	New
Ammonia Release Mitigation System – ARMS	System used to mitigate the risks associated with ammonia where vapours are treated to reduce emissions related to ammonia content, nitrous oxides (N_2O), nitrogen oxides (NOx) and ammonia slip.	New
Boiling Liquid Expanding Vapour Explosion – BLEVE	The term used to describe an explosion resulting from the catastrophic failure of a vessel containing a liquid significantly above its boiling point at normal pressure.	LR
Catastrophic release	An uncontrolled loss of containment of toxic, reactive, or flammable materials that has the potential for causing acute health effects, significant environmental effects, or significant property damage.	Modified from AICHE CCPS
Catch Tank	A separate containment vessel intended to receive an emergency discharge from relief devices in the process vessel's vapor space. Catch tanks are usually employed where substantial two-phase relief flow, entrained solids, or reaction mass carryover is expected to occur.	ISGOTT

Term / Abbreviation	Description	Source
Competency	The combination of knowledge, skill, expertise, and training needed to deem someone as well-qualified and capable. The capability to undertake a task and complete it successfully with confidence and understanding.	Adapted from AICHE CCPS SGMF
Conditioning	The state of the fuel in which it needs to be presented to the end consumer or to serve its intended purpose.	Wartsila
Confined space	See enclosed space	
Deflagration	Combustion process in which a flame or chemical reaction moves through a flammable mixture at a rate less than the speed of sound in the unburnt mixture.	LR
Detonation	Shock stabilised combustion process resulting in a combustion phenomenon propagating faster than the speed of sound.	LR
Earthing	The electrical connection of equipment to the main body of the earth to ensure that it is at the earth potential. On board ship, the connection is made to the main metallic structure of the ship, which is at earth potential because of the conductivity of the sea.	ISGOTT
Emergency Shut Down (ESD) system	A quick closing system which may be activated automatically or manually. It will close valves and shutdown machinery to isolate a system. A control system and associated components that when activated stop operations in a controlled manner, returning a system to a safe state.	 SGMF
Emergency Escape Breathing Devices – EEBD	A self-contained compressed air apparatus for escape from a contaminated environment. It consists of a compressed air cylinder with air capacity of 600 litres (15 minutes duration).	Wartsila
Emergency Response Gear	Emergency gear is the items / clothing for responding to an emergency versus PPE used for normal working conditions. Emergency response gear includes the equipment and gear that needs to be used in tackling an emergency, encapsulated suits, hazardous release equipment, oil spill containment booms and deployment equipment, extinguishers, hose carts, SCBA equipment, and other equipment necessary or desirable to respond to emergencies.	Adapted from Law Insider

Term / Abbreviation	Description	Source
Enclosed Space	Enclosed space (IMO) – **Revised recommendations for entering enclosed spaces aboard ships (Resolution A.1050(27), 20 December 2011)** 2.1 Enclosed space means a space which has any of the following characteristics: .1 limited openings for entry and exit, .2 inadequate ventilation; and .3 is not designed for continuous worker occupancy. Examples given included cargo compressor rooms	IMO
	A space that has limited openings for entry and exit, unfavourable natural ventilation, and where it is foreseeable that a risk of death or serious injury may exist making it unsuitable for continuous worker occupancy.	ISGOTT
Entry Permit	A document issued by a Responsible Person on completion of all required preparation and testing allowing entry into a space or compartment during a specific time interval.	ISGOTT
Familiarisation	Basic information or instructions related to the various aspects of a topic. An orientation to promote awareness of essential technical, safety, environmental or security information related to a seafarer's duties.	New
Gas Free	A tank, compartment or container is gas free when it has been adequately cleaned and sufficient air has been introduced into it to lower the level of any flammable, toxic or inert gas to that required for a specific purpose e.g., hot work, entry, etc.	Adapted from ISGOTT
Gassed up	A piece of equipment or pipework where gas is or may be present. By extension, where a liquid is present which may vaporise to create a gas.	Adapted from SGMF
General ammonia alarm	An audible and visible alarm used to alert those present to the detection of ammonia above a pre-determined level. Similar to fire alarms or to those used for carbon dioxide in engine spaces.	
Hazard	A potential source of harm or adverse effect.	LR
Hazardous Area or Zone	Any place in which an atmosphere that may occur to require special precautions to protect the safety of workers. For ammonia, this could relate to hazards such as toxicity, flammability or explosivity. The hazardous areas could relate to restricted access areas of zone such as: ↗ Safety zones ↗ Security zones ↗ Marine zones ↗ Toxic areas or spaces with potential ammonia levels above 220 ppm.	Adapted from ISGOTT SGMF, IMO CCC 10.

Term / Abbreviation	Description	Source
Inert condition	A condition in which the oxygen content throughout the atmosphere of a tank has been reduced to 8% or less by volume by the addition of an inert gas.	ISGOTT
Inerting	The process of introducing an inert gas into a tank with the object of attaining the inert condition.	ISGOTT
Inert gas	A gas such as nitrogen used to reduce moisture content and eliminate carbon dioxide.	Adapted from ISGOTT
Invasive maintenance	A type of maintenance that involves physically interacting with equipment of machinery to inspect, repair or replace components. This often involves internal components and in the case of ammonia, has the potential for human exposure.	New
Job Safety Analysis JSA	A procedure that systematically identifies: 1) job steps, 2) specific hazards associated with each job step, and 3) safe job procedures associated with each step to minimise accident potential. Also called job hazard analysis.	AICHE CCPS
Knockout Pot or Drum	A vessel used to separate liquids from vapours.	ISGOTT
Knowledge	Facts, information, and skills acquired by a person through experience or education. A basic familiarity with facts and information about a topic. It means possessing the necessary information to identify and describe the key aspects of the subject.	Oxford Languages Bloom et al.
Lock out – Tag out LOTO	A safety procedure used to ensure that dangerous machines are properly shut off and not able to be started up again prior to the completion of maintenance or repair work. It requires that hazardous energy sources be isolated and rendered inoperable before work is stared on the equipment in question.	Wartsila
Lower Explosive Limit – LEL	The lower explosive limit also commonly referred to the lower flammability Limit (LFL). It is the lowest concentration that will produce a flash fire when an ignition source is present.	LR
Management of Change	A management system to identify, review, and approve all modifications to equipment, procedures, raw materials, and processing conditions, other than replacement in kind, prior to implementation to help ensure that changes to processes are properly analysed (for example, for potential adverse impacts), documented, and communicated to employees affected.	AICHE CCPS
Materials	Materials in this document includes metals as well as substances such as rubber, polymers such as plastics, elastomers, and sealants.	NEW
Occupational Health and Safety	Safety area that focuses on preventing work-related injuries and illness while promoting the health and wellness of individuals.	AICHE CCPS

Term / Abbreviation	Description	Source
Permit to work – PTW	A document issued by a Responsible Person on the completion of all required preparation and testing, which allows work to be performed in compliance with the ship's Safety Management System (SMS).	ISGOTT
Permit to Work Systems	A documented system for controlling activities that expose the ship, the terminal, personnel or the environment to hazard. The system will use risk assessment techniques and apply them to the varying levels of risk that may be experienced. The system should conform to a recognised industry standard.	ISGOTT
Personal Protection Equipment PPE	PPE are equipment that are designed to protect the crew against any health or safety risks at work. Protective clothing, helmets, goggle, or other garments or equipment designed to protect the wearer's body from injury or infection. The purpose is to reduce employee exposure to hazards when engineering controls or administrative control are not feasible or effective to reduce these risks to acceptable levels.	Skuld (SGMF) Wartsila
Process Safety	An aspect of safety management that includes the management system and processes intended to reduce the risk of major or catastrophic incidents that typically involve uncontrolled releases of hazardous process materials. A disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices. The focus is on reducing the frequency and consequences of potential incidents including toxic or flammable material releases (loss events), resulting in toxic effects, fires, or explosions. The incident impact includes harm to people (injuries, fatalities), harm to the environment, property damage, production losses, and adverse business publicity.	AICHE CCPS
Proficiency	A high degree of competence or skill; expertise	Oxford Language
Purging (of ammonia)	Process of removing ammonia from a closed system such as tanks, piping and equipment. This can be done by applying pressure or a purge gas. It's used when starting up or shutting down operations to eliminate moisture, carbon dioxide and other gases.	Adapted from AICHE CCPS
Refrigerated liquid	A gas that is maintained as liquid at temperatures at or below ambient temperature to reduce the storage pressure. This includes fully refrigerated and semi refrigerated gases.	Adapted from AICHE CCPS
Replacement in Kind (RiK) or Like-for- Like	Like for Like or Replacement in Kind is where an item (equipment, chemical, procedure, etc.) meets the design specification of the item it is replacing. This can be an identical replacement or any other alternative specifically provided for in the design specification, as long as the alternative does not in any way adversely affect the use of the item or associated items.	Adapted from AICHE CCPS
Risk	Exposure to a hazard.	ISGOTT

Term / Abbreviation	Description	Source
Risk Assessment	The process that collects information and assigns values to risks for informing priorities, developing or comparing course of action and informing decision making.	LR
Residues	Remains such as any fluid or materials that potentially contain or have come into contact with ammonia, resulting in contamination. These materials can be solid, liquid or semi-solid. Residues can be the remains from combustion or evaporation. Residues can be hazardous or non-hazardous and can be detrimental to the environment if not handled properly. They can pollute water resources and the environment. Proper handling and disposal is required and thus these may be sent ashore when there is no means onboard to eliminate them.	Adapted from AICHE CCPS and US EPA
Safeguard	Means to prevent or mitigate a hazard and / or its consequences.	LR
Safety Zones	The zone around the bunkering facility, the bunkering station of the receiving ship and the fuel transfer system. The purpose of the zone is to set an area that is put in place during fuel bunkering and within which only essential authorised and qualified personnel are allowed and potential ignition sources are controlled. As a zone, distances should be calculated based on hazard scenarios and location conditions.	Adapted from SGMF
Safe Work Practices SWP	An integrated set of policies, procedures, permits, and other systems that are designed to manage risks associated with non-routine activities such as performing hot work, opening process vessels or lines, or entering a confined/enclosed space.	AICHE CCPS
Sloshing	A particular motion of liquid inside a tank due to ship motion (rolling, pitching, etc.)	LR
Stress Corrosion Cracking	A failure mechanism that can occur in components exposed to a corrosive medium such as ammonia and subject to tensile stress. The resulting cracks and fractures may lead to sudden catastrophic failure.	LR
Threshold Limit Value	Airborne concentration of substances under which it is believed that nearly all workers may be exposed day after day with no adverse effect. The maximum exposure concentration recommended by the American Conference of Government Industrial Hygienists (ACGIH) for long term exposures. ACGIH expresses Threshold Limit Values (TLV's) in three ways; TLV-TWA, TLV-STEL, and TLV-CL. TLV's are reviewed and revised annually where necessary by the ACGIH. If a TLV is exceeded, a potential health hazard exists and corrective action is necessary.	ISGOTT and ACGIH
Threshold Limit Value – C	The concentration in air that should not be exceeded during any part of the working exposure. Ceiling limits may supplement other limits or stand alone.	ACGIH

Term / Abbreviation	Description	Source
Threshold Limit Value – STEL	Maximum concentration for an allowable period of time, usually 15-minute exposures with a limit on the number of exposures per day or with stated time breaks between exposures. TLV STEL A 15-minute, time -weighted average concentration to which workers may be exposed up to four times per day with at least 60 minutes between successive exposures with no ill effect if the TLV-TWA (see below) is not exceeded. The limit supplements the TLV-TWA where there are recognised acute effects from a substance with toxic effects that result primarily from chronic exposures.	ACGIH
Threshold Limit Value – TWA	Concentration for work period; by day or week. Expressed in ppm or milligrams of substance per cubic meter of air (mg/r). The time-weighted average concentration limit for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.	ACGIH
Toxic Areas or Spaces	An area or space where there is a potential for humans to be exposed to potential ammonia levels above 220 ppm.	Adapted from CCC 10
Toxicity	The degree to which a substance or mixture of substances can harm humans or animals. Acute toxicity involves harmful effects to an organism through a single short-term exposure. Chronic toxicity is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposures, sometimes lasting for the entire life of the exposed organism.	OCIMF
Understanding	To comprehend the direct meaning of the information learnt. The power of comprehending. especially the capacity to apprehend general relations of particulars. Understanding infers a deeper insight into how and why this knowledge is relevant and can be practically applied. It also entails the ability to comprehend and relate knowledge to specific situations and make decisions based on this insight.	Adapted from: IMO Oxford Languages Bloom et al.
Upper Flammability Limit (UFL)	The concentration of a gas in air above which there is insufficient oxygen to support or propagate combustion. Sometimes referred to as Upper Explosive Limit (UEL).	Adapted from OCIMF
Vapour	A gas below its critical temperature.	ISGOTT
Ventilation	The process of removing or supplying an atmosphere to or from a space, either by mechanical or natural means. For ammonia, ventilation is often used for dilution or dispersion purposes.	Adapted from AICHE CCPS

Term / Abbreviation	Description	Source
Venting	Emergency flow of contents out of a tank. The pressure is controlled or reduced by venting, thus avoiding a failure of the tank by overpressurisation. The emergency flow can be one-phase or multi-phase, each of which results in different flow characteristics.	Adapted from AICHE CCPS
Water Fog	A suspension in the atmosphere of very fine droplets of water, usually delivered at a high pressure through a fog nozzle for use in firefighting.	ISGOTT
Water Spray	A spray of water divided into coarse drops by delivery through a special nozzle.	Adapted from ISGOTT

Appendix 3: Reference Material

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STCW Code Table A-V/1-1-2 – Specification of minimum standard of competence in advanced training for oil tanker cargo operations.

STCW Code Table A-V/1-1-3 – Specification of minimum standard of competence in advanced training for chemical tanker cargo operations

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Appendix 4: Acknowledgements

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The Decarb Hub LR