RECOMMENDED PRACTICE

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Competence related to the use of ammonia as fuel

DNV AS

FOREWORD

DNV recommended practices contain sound engineering practice and guidance.

Any comments may be sent by e-mail to *rules@dnv.com*

CHANGES – CURRENT

This is a new document.

CONTENTS

SECTION 1 GENERAL

1.1 Introduction

Safe operation of vessels using ammonia as fuel will require changes to the safety management system, potentially affecting the organizational structures, and certainly generate the need for new competencies on board and ashore. It is also crucial to emphasize the significance of the crew on board and the organizational factors when considering proactive risk controls and risk mitigation for potential ammonia release scenarios, in addition to technical safety measures and safety in design. Adhering to organizational policy and procedures that foster a proactive safety culture is essential for maintaining safety. Therefore, a proactive mindset, driven by a mature safety culture, should be the standard for the crew and the shipowner.

This recommended practice (RP) is developed using the DNV methodology for DNV competence standards. Industry contributions, mature concepts of ammonia as a marine fuel, and experience with trading ammonia as cargo, have been applied to the development process. However, this document is not to be regarded as a DNV competence standard, as competence standards are based on extensive practical user experience. Currently, no such user experience exists for ammonia fuelled vessels. As the industry experience grows and when such user experience is available, the goal is for this document to evolve into a DNV competence standard.

The foundation of seafarer competence lies in the standards of training, certification, and watchkeeping (STCW). This recommended practice is not a substitution of STCW requirements but should rather act as a supplement to provide advanced guidance for organizations considering the use of ammonia as a marine fuel.

This document serves as input to defining competence and recommended training requirements for shipboard crew which use ammonia as (dual) fuel. The recommended practice focuses on ensuring that crew on board, possesses the required competence to operate the ammonia fuel system. This includes specific competencies related to the fuel systems and arrangements, operational and emergency procedures, and the unique safety hazards associated with the characteristics of ammonia.

Despite the recommended practice providing extensive information on what competence which is recommended for crew on board an ammonia fuelled vessel, it is not intended that all crew must have competence within one category, regarding all listed requirements. The recommendation is that the competence should exist among the crew.

The recommended practice addresses three (3) crew categories as defined in Table 1-1.

Table 1-1 Crew categories

Category	*Target group*
A - All crew	Basic competence requirements for all crew regardless of role, function, or department.
B - Deck	Competence requirements for crew in deck department (officers and deck ratings).
C - Engine	Competence requirements for crew in engine department (officers and engine ratings).

Guidance note:

The required level of competence is always determined by the role, task or responsibility assigned to a person within an organization. If a responsibility is transferred from one department or person to another (e.g. bunkering), this would affect the competence needs. It is the responsibility of the ship owner to ensure that the right people possess the right competence.

The IGF code divides between 'Basic' and 'Advanced' training. It is however applicable to understand that categories as A-All crew - is related to 'basic training' while B-Deck and C-Engine, depending on the levels of cognition, as described in [2.2], can be related to both 'Basic' and 'Advanced training' in the STCW framework.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.2 Objective

The purpose of the recommended practice is to contribute to enhanced safety in the maritime industry by supporting the onboard implementation of ammonia as fuel. Ammonia is yet to be implemented as a marine fuel, and until mandatory regulations are in place, the IMO's risk-based approval methodology applies. Hence, technical safety considerations based upon hazards and risks are thoroughly considered in designs that are under development. Still, there is a need for collaborative efforts and high focus on operational safety when introducing ammonia into the new context as a marine fuel.

The objective of this RP is to define recommended expected competence, which enables organizations to assess and verify knowledge and skills of crew related to the onboard use of ammonia as (dual) fuel. It is aimed at risk reduction, fostering a risk-based mindset and a proactive safety culture to ensure the safe and sustainable use of ammonia as a fuel.

1.3 Scope

This document covers recommended competencies for three categories of crew on board a vessel which uses ammonia as a marine fuel. It aims to provide guidance for establishing a competence foundation and may be supplemented by operational manuals and system-specific details.

Other personnel, as bunkering personnel ashore, service and maintenance personnel, or other visitors who are not a part of the normal vessel crew, is not considered in this recommended practice. This RP has been developed based on theoretical considerations, involving relevant industry partners, to the best of our knowledge.

Operational scope and detailed knowledge, understanding and performance expectations are defined in Sec.3.

1.4 Application

This RP can be used in the following ways:

- as a reference to familiarize people or assess required performance for their specific role in relation to ammonia as fuel
- as a reference for global competence and defining training requirements
- as a guide to training providers, who shall develop courses according to the requirements of the recommended practise and the needs of the industry
- as a reference document for e.g. certification of learning programmes or persons
- as a reference to establish vessel specific operational and preparedness manuals.

1.5 References

Table 1-2 lists DNV references used in this document.

Table 1-2 DNV references

Document code	*Title*
DNV-ST-0008	Learning programmes
DNV-ST-0029	Maritime training providers
DNV-ST-0033	Maritime simulator systems

Table 1-3 lists other references used in this document.

Table 1-3 Other references

Document code	*Title*
IGF Code	International Code of Safety for Ships using Gases or other Low flashpoint Fuels
ISM Code	International Safety Management Code
SOLAS	International Convention for the Safety of Life at Sea
STCW Convention	International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers

1.6 Definitions and abbreviations

1.6.1 Definition of verbal forms

The verbal forms defined in Table 1-4 are used in this document.

Table 1-4 Definition of verbal forms (normative)

Term	*Definition*
shall	verbal form used to indicate a requirement strictly to be followed
should	verbal form used to indicate that among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others
may	verbal form used to indicate a course of action permissible within the limits of a requirement

1.6.2 Definition of terms

The terms defined in Table 1-5 are used in this document.

Table 1-5 Definition of terms

Term	*Definition*
assessment	act or result of judging the worth or value of something or someone In this context, normally whether a candidate can perform the tasks, duties, and responsibilities related to a specified competence or job description.
cognition	mental action or process of acquiring knowledge and understanding
competence	knowledge, understanding, skills, attitude and/or behaviour in a defined area of work
EX-equipment	equipment designed for use in potentially explosive atmospheres
hazardous area	area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment
taxonomy	categorization of different cognitive levels of understanding and skills
toxic zone	areas on open deck where the probability of having health-affecting concentrations of ammonia vapour is high

1.6.3 Abbreviations

The abbreviations described in Table 1-6 are used in this document.

Table 1-6 Abbreviations

Abbreviation	*Description*
AEGL	acute exposure guideline levels
ARMS	ammonia release mitigation system
CUI	corrosion under isolation
ESD	emergency shutdown
EX	explosion
FME(C)A	failure mode effect and criticality analysis
FPR	fuel preparation room
GCU	gas combustion unit
GDA	gas dispersion analysis
HAZID	hazard identification
HAZMAT	hazardous materials
IDLH	immediately dangerous to life or health
LAH	level alarm high
LAL	level alarm low
LOTO	lockout-tagout
OEL	occupational exposure limit
P&ID	piping and instrumentation diagram
PAH	pressure alarm high
PAL	pressure alarm low
PEM	proton-exchange membrane
PEL	permissible exposure limits
PPE	personal protective equipment
PSV	pressure safety valve
QCDC	quick connect / disconnect
SCC	stress corrosion cracking
SCR	selective catalytic reduction
SDS	safety data sheet
SOFC	solid oxide fuel cell
SPEL	short-term public emergency guidance level

Abbreviation	*Description*
STCW	standards of training, certification, and watchkeeping
TCS	tank connection space

SECTION 2 TAXONOMY

2.1 General

Taxonomy is a structured hierarchy arranged in four (4) cognition levels that crew shall master, ranging from simple to intricate cognitive processes based on varying levels of complexity instructional design principles. Each subsequent level necessitates mastery of the previous one. The required professional competence behaviour is expressed through verbs.

2.2 Levels of cognition

Each recommended competence requirement can be classed by the level of cognition as defined in Table 2-1.

Table 2-1 List of verbs used for each level of cognition[1)]

Level number	*Level of cognition*	*Definition*	*Example*
1	Knowledge (K)	to remember or to reproduce on the basis of appropriate, previously learned information	The crew must be able to list, memorize and recognize substance properties, toxicity, flammability and hazards related to ammonia.
2	Understanding (U)	to give meaning to situations and or material by recollecting and using necessary present information, and to give evidence of insight into certain activities	Understand how ammonia must be stored, controlled and monitored.
3	Application (A)	to use previously acquired information in new and known/concrete situations to solve problems that have single or best answers This could typically be to apply a procedure to a pre-defined/known situation.	Crew should be able to operate the ammonia fuel supply system and respond to an operation upset or deviations, i.e. an ammonia leak, by following established procedures.
4	Integration (I)	to judge, value or argue a solution or a decision to separate information into its component parts, and to examine such information to develop divergent conclusions by identifying motives or causes, making inferences, and/or finding evidence to support generalizations. use of combination of competencies to evaluate, decide and hence manage complex situations	At the time of an accident, crew may advance the predefined incident response to adapt and manage it effectively and safely.
1) Harmonized with the STCW level of cognition where knowledge (K) and understanding (U) is the same in the table and in the STCW framework and where (A) and (I) in this table is corresponding to proficiency (P) in the STCW framework.			

Competence is a combination of knowledge, skills and attitudes, and the level of cognition may change due to the experience and implementation of ammonia as fuel. To avoid confusion, the reader should not be confused between the mixing between knowledge in competence and knowledge in levels of cognition. The different levels will influence each other and have overlapping characteristics. The recommended competence activities in this guideline must be related to ammonia and system specific characteristics, such as ship type, fuel system, ship trade, and so on.

2.3 Professional behaviour verbs

The list of verbs in Table 2-2 are not exhaustive and should be used as guidance only.

Table 2-2 List of verbs used for each level of cognition

Level of cognition	*Relevant action verbs*
Knowledge (K)	choose, cite, describe, distinguish, find, give example, group, identify, indicate, know, label, list, listen, locate, match, memorize, name, outline, quote, read, recall, recognize, record, recite, relate, repeat, reproduce, retrieve, review, select, show, sort, state, underline, write
Understanding (U)	account for, annotate, associate, classify, compare, define, describe, discuss, estimate, exemplify, explain, give examples of, give a main idea, identify, infer, interpret, observe, outline, paraphrase, recognize, reorganize, report, restate, retell, research, review, summarize, translate
Application (A)	adapt, apply, arrange, calculate, carry out, change, collect, compute, conclude, construct, demonstrate, dramatize, draw, exhibit, execute, extract, illustrate, implement, include, instruct, interpret, interview, make, manipulate, obtain, operate, paint, practice, prepare, sequence, show, sketch, solve, translate, use
Integration (I)	analyse, appraise, argue, arrange, assess, attribute, calculate, categorize, check, choose, combine, compare, contrast, criticize, critique, debate, decide, deconstruct, deduce, defend, design, detect, determine, develop, diagram, differentiate, discriminate, dissect, distinguish, evaluate, examine, experiment, find, formulate, group, hypothesize, infer, investigate, integrate, interpret, inspect, inquire, judge, justify, measure, monitor, order, organize, outline, plan, predict, prioritize, probe, question, rank, rate, recommend, reject, relate, research, revise, score, separate, select, sequence, sift, structure, survey, tell why, test, validate, value

SECTION 3 RECOMMENDED COMPETENCE REQUIREMENTS

3.1 General

This section contains specified tables listing recommended competence requirements which were derived from activities that shall be performed on board an ammonia fuelled vessel. These are formulated in an objective and measurable format, defining what shall be demonstrated and facilitating the derivation of assessment criteria and development of assessments to measure individual competence.

Each recommended competence requirement is allocated a level of cognition that may be used to determine the type of assessment required.

The recommended competence requirements for this role require both theoretical knowledge and intellectual and physical skills. Performance shall be demonstrated and assessed.

The recommended competence requirements are separated into specific themes. The general knowledge will be addressed first, before acquiring knowledge on handling technical systems and equipment. Finally, operations and activities will be described, such as maintenance and emergency preparedness and handling.

3.2 Operational scope

The guideline identifies a suggested minimum level of competence for people on board a vessel using ammonia as fuel, considering their category as mentioned in Table 1-1. The defined competencies shall be considered in conjunction with the responsibility actually given to a person since ranks, tasks and delegated responsibilities on board may differ from company to company. Anyone who is made responsible for an activity shall be competent in that activity.

Specific details related to all vessel-specific arrangements and systems cannot be captured in a guideline of a generic nature. However, it aims to provide guidance for establishing a competence foundation, to be supplemented by e.g. operational/supplier manuals or equipment-specific instructions and/or training by manufacturers.

The scope does not include recommended competence requirements for vessel crew engaged in handling ammonia as cargo, nor for vessels involved in transporting ammonia as cargo. Furthermore, systems not related to ammonia fuel system and competence in relation to other non-ammonia procedures and standard emergency procedures, e.g. firefighting and first aid are not covered in detail in this RP.

3.3 Professional profile

3.3.1 General

Crew members on board an ammonia-fuelled vessel, as categorized in Table 1-1, will adhere to all international, national, and local regulations and requirements. They are committed to operating the vessel and its equipment safely, ensuring no harm comes to life, the environment, or property.

Table 3-1 through Table 3-10 define the expected competencies directly related to the maritime use of ammonia as fuel. It focuses on related technology, activities, and risks to which crew members may not previously have been exposed.

3.3.2 General competence

Table 3-1 Recommended general competence requirements

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
1.1	*Physics and chemistry*				
1.1.1	Interpret the safety data sheet (SDS) for ammonia.	A		•	•
1.1.2	Explain the physical and chemical properties of ammonia, including boiling temperature, vapour pressure, specific gravity, expansion range liquid/gas, phase diagram, flammability range, minimum ignition energy, auto-ignition temperature, burning velocity and the explosive profile.	U		•	•
1.1.3	Explain the ammonia release characteristics, depending on storage condition, including boil-off, visible cloud, dispersion, forced evaporation, vapour buoyancy, factors affecting density, hygroscopic effects, expansion ratio liquid to gas, release in confined and open spaces.	U		•	•
1.1.4	Explain the exothermic reaction between liquid/gaseous ammonia and water, and its associated consequences.	U		•	•
1.1.5	Describe the corrosive properties of ammonia and the effect of ambient temperature, water/humidity- and oxygen content on the corrosivity, and how stress corrosion cracking (SCC) differs from other types of corrosion, and list incompatible materials with ammonia.	A		•	•
1.1.6	Describe the possible toxic and corrosive properties of ammonia mixtures and exhaust, such as characteristics relevant to (dual) fuel exhaust and ammonia mixed with other substances, such as lube oil.	A		•	•
1.1.7	Describe how other substances potentially can contaminate ammonia and impact the performance on the ammonia fuel system, e.g.: — lube oil can impact ignition characteristics — water content can affect dew point and SCC.	A			•
1.1.8	Describe how the low storage temperature of ammonia and vaporization effect affects standard steel components upon contact.	U		•	•
1.1.9	Explain the Joule-Thomson effect and the risks it presents (pressurized systems only).	U		•	•
1.2	*Risk awareness, safety and health*				
1.2.1	State the applicable rules and regulations related to the use of ammonia as fuel in the maritime sector, including SOLAS, IGF, and class rules.	U		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
1.2.2	Understand the toxic properties of ammonia and dangerous exposure threshold levels to humans, including concept of dose (concentration and duration of exposure) and difference between chronic and acute exposure.	A	•	•	•
1.2.3	Understand the fundamental safety hazards associated with ammonia, including its flammability, health effects, risk of frost burns, and dangers from inhalation, as well as skin and eye contact.	U	•	•	•
1.2.4	List different standards for acute exposure guideline levels, e.g. — acute exposure guideline levels (AEGL) — immediately dangerous to life or health (IDLH) — permissible exposure limits (PEL) — short-term public emergency guidance level (SPEL).	K		•	•
1.2.5	Explain proactive risk reducing measures to mitigate ammonia hazards, including precautions, work permits, PPE and purging/inerting.	U	•	•	•
1.2.6	Recognize the importance of immediate reporting of susceptible ammonia leak, smell, and exposure.	A	•	•	•
1.2.7	Perform basic first aid/medical treatment in case of possible health consequences due to ammonia exposure.	A	•	•	•
1.2.8	Describe how equipment can be contaminated due to ammonia exposure.	U	•	•	•
1.2.9	Explain risks of entering enclosed and semi-enclosed spaces with potential ammonia leakage sources, such as single-walled piping, pumps, flanges, valves, filters, etc.	U	•	•	•
1.2.10	Explain the risks of entering spaces containing nitrogen systems.	U	•	•	•
1.3	*Human, organizational and technical safety barriers*				
1.3.1	Describe the technical safety concept of current regulations in the IGF Code for gas-fuelled vessels, including fuel preventive and mitigating safety barriers such as segregation, system integrity, double barriers, leak detection, ventilation and isolation of leakages.	U		•	•
1.3.2	Describe credible risk scenarios where ammonia may be released from the fuel system.	U		•	•
1.3.3	Describe how the human is considered as a safeguard to proactively identify a deviation in the technical systems which may pose a risk to the vessel and the crew by e.g.: — proactively monitor the system status and alarms — keep control of the technical integrity including all barriers — recognize and act upon unexpected process deviations.	A		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
1.3.4	Describe, in general terms, how the human is considered as a safeguard to mitigate the consequences of ammonia release, referring to the vessel's emergency procedures, including ensuring leak isolation, control of situation, communication, etc. See detailed requirements for emergency and contingency in section 3.3.10.	A		•	•
1.3.5	Describe the fundamental principle and sequences of technical barriers to mitigate the consequences of ammonia release into spaces and double-walled piping, including (but not limited to) gas detection, automatic closing of the relevant valves (e.g. tank valves, the master fuel valve and the double-block and bleed valves), start of catastrophe ventilation, automatic purging of the leaking pipe segment to ammonia release mitigation system (ARMS), automatic activation of water spray system, etc.	U		•	•
1.3.6	Describe operational procedures and technical arrangements for how to respond to substantial discharges from the outlet from fuel tank pressure relief valves or ventilation openings from toxic spaces, including: — evacuation to safe haven — closing of ventilation inlets — operation of water spray systems to limit extent of toxic vapours. See detailed requirements for emergency and contingency in section 3.3.10.	A		•	•
1.3.7	Interpret the organizational factors affecting safety of the ammonia fuel supply system, e.g. procedural framework, policy and safety management system, safety culture, organizational structure, roles and responsibilities.	A	•	•	•
1.3.8	Interpret the operational safety barriers relevant for working on an ammonia fuelled vessel, including where related guidance documents can be found within the safety management system, e.g.: — procedures and checklist — self-check — toolbox talk — safe job analysis — risk analysis — permit to work.	A	•	•	•
1.3.9	Execute risk assessment prior to vessel operations, such as tank conditioning, bunkering and maintenance.	A		•	•
1.4	*Personal protection equipment (PPE)*				
1.4.1	Describe the minimum PPE required for crew not involved in handling ammonia system.	U	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
1.4.2	Describe the minimum personal protection equipment (PPE) required when working with ammonia fuel systems depending on activity/task, such as normal operation, maintenance, bunkering, and entry into enclosed spaces with potential ammonia leakage sources. Equipment includes, but is not limited to: — gloves, footwear, eye, or face protection, etc. — air breathing apparatuses — HAZMAT suit — personal gas detection equipment.	U		•	•
1.4.3	Describe the safety, integrity, and usage of PPE needed when working on ammonia systems, lines, and manifolds which may contain ammonia, e.g. breathing apparatus and chemical suit.	A		•	•
1.4.4	Carry out decontamination procedures for PPE, explain single- and multiple-use types of PPE, how to safely dispose of used PPE equipment.	A		•	•
1.4.5	Explain purpose and principles of operation of different portable gas detection instruments.	U	•	•	•
1.4.6	Calibrate and use portable gas detection equipment.	A		•	•
1.4.7	Demonstrate the correct use of available rescue and escape equipment, such as emergency escape breathing equipment and gas masks.	A	•	•	•
1.5	*Safe haven, hazardous and toxic areas/spaces*				
1.5.1	Explain vessel specific safe haven and relevant functionalities of typical arrangements.	U	•	•	•
1.5.2	Demonstrate the vessel specific escape routes, including escape trunks, to safe haven, muster station and embarkation station.	A	•	•	•
1.5.3	Explain the definition of toxic spaces/areas and identify the relevant spaces/areas on board, in open air, enclosed or semi-enclosed spaces. Examples of such spaces/areas: — tank connection spaces and fuel preparation room — ventilation outlets — vent mast — bunkering station.	U	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
1.5.4	Explain the hazardous areas on board, the operational limitations in those areas and equipment constraints in such areas. Examples of spaces subject to hazardous zone classification: — zone 0: e.g. interiors of fuel tanks, pipes and equipment containing fuel, any pipework of pressure-relief or other — venting systems for fuel tanks — zone 1: e.g. tank connection spaces, fuel preparation rooms, fuel storage hold spaces, interbarrier spaces, enclosed bunkering stations and other enclosed spaces where leakage of ammonia may occur — zone 2: e.g. air locks.	U	•	•	•

3.3.3 The ammonia bunkering and fuel containment system

Table 3-2 Recommended competence requirements for handling the ammonia bunkering and fuel containment system

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
2.1	*Fuel containment system*				
2.1.1	Describe the different tank types used for onboard storage of ammonia as fuel, e.g. type A, type B, and type C, including the fundamentals of their arrangement, principle for leak detection, protection and requirements for secondary barrier.	U		•	•
2.1.2	Explain the principal design and arrangement of secondary barriers for Type A tanks, including number of days capable of containing any envisaged leakage, limitations with respect to static angle of heel, etc.	U		•	•
2.1.3	Explain the principal design and arrangement of partial secondary barriers for type B tanks, including number of days capable of containing any envisaged leakage, limitations with respect to static angle of heel, its leak protection system, etc.	U		•	•
2.1.4	Recognize that no secondary barrier is required for type C tanks (independent tanks), where the probability for structural failures and leakages through the primary barrier is extremely low and can be neglected.	K		•	•
2.1.5	Describe SCC in the tank and ways to detect and prevent it.	U		•	•
2.1.6	Describe possible failure causes relating to leakages in fuel containment system, including preventive and mitigating safety measures, in tank and tank connections.	U		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
2.1.7	Identify possible failure causes relating to external events and risk of mechanical, damage from ship operations, cargo operations and green seas in fuel containment system, including preventive and mitigating measures.	U		•	•
2.1.8	Explain the difference between tank, tank connection space and tank hold space, and location of these spaces (above and below deck).	U		•	•
2.1.9	Demonstrate methods of preparing tank for receiving ammonia (starting from gas freeing stage after new delivery or drydocking).	A		•	•
2.1.10	Outline the inspection/survey plan for the tank, including aspects to be examined and/or validated during inspections, any necessary in-service survey, maintenance and/or testing, as well as specific critical locations on the tank.	A			•
2.1.11	Carry out external inspections of the fuel tank and supports Carry out external inspections of the fuel tank and supports.	A			•
2.1.12	Evaluate inspections of the fuel tank thermal insulation system, if applicable.	I			•
2.1.13	Evaluate inspections of complete and partial secondary barriers for its effectiveness by means of a visual inspection or other suitable means (pending on tank type), if applicable.	I			•
2.1.14	Outline methods of emptying/gas freeing the tank.	A			•
2.1.15	Describe means of access for internal inspection of fuel tanks, including arrangement for horizontal openings, hatches or manholes. See detailed requirements for tank internal maintenance in section 3.3.8.	U		•	•
2.1.16	Interpret readings from local instruments and the integrated automation system (IAS), including gement, trip logic, etc.	A			•
2.2	*Bunkering arrangement*				
2.2.1	Describe typical and ship specific bunkering arrangements for ammonia.	U		•	•
2.2.2	Analyse possible failure causes and mechanisms to bunkering system.	A		•	•
2.2.3	Understand the purpose and function of dry-connect/ disconnect type couplings (QCDC) for normal operation.	U		•	•
2.2.4	Understand the purpose and function of safety breakaway coupling (emergency release coupling).	U		•	•
2.2.5	Explain the risks, benefits, and safety philosophy associated with each type of bunkering station arrangement, i.e. open, semi-enclosed, enclosed.	U	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
2.2.6	State the maximum loads/limitations of the bunkering arrangement (vessel side).	K		•	•
2.2.7	Explain how the different ammonia storage concepts (fully refrigerated, semi-refrigerated and pressurized ammonia storage systems) will influence the bunkering operation.	U		•	•
2.2.8	Explain how the different ammonia storage concepts (fully refrigerated, semi-refrigerated and pressurized ammonia storage systems) will influence material compatibility requirements for ammonia, transfer hose, gasket, etc.	U		•	•
2.2.9	Interpret bunkering transfer diagrams	I			•
2.2.10	Recognize various safety devices fitted in fuel bunkering system from P and ID provided in ship's drawings.	I		•	•
2.2.11	Demonstrate a proactive approach with regards to preventive maintenance, systematic inspection, testing and validation of safety devices fitted in fuel bunkering system to always ensure required functionality.	I			•
2.3	*Tank connection space (TCS)*				
2.3.1	Describe the overall purpose and main functions of a TCS.	U		•	•
2.3.2	Describe typical equipment located in a TCS, including valves, sensors, vaporizer.	U		•	•
2.3.3	Interpret credible leak scenarios in TCS.	A		•	•
2.3.4	Describe all interfaces and auxiliary systems to the TCS, including instrument air, draining, ventilation, etc.	U		•	•
2.3.5	Analyse the risk and preventive measures to avoid that ammonia leakage in TCS reaches other non-hazardous spaces via interfaces such as the heating media system for vaporizers or inert gas system.	I		•	•
2.3.6	Describe the safe working procedure for entering and working in the TCS.	U		•	•
2.4	*Fuel storage condition and tank pressure relief system*				
2.4.1	Explain the purpose of the tank pressure relief valves. See detailed competence requirement for fuel gas venting system in section 3.3.4.	U		•	•
2.4.2	Explain the need for mechanical opening/closing interlocks between isolation valves before and after pressure relief valves.	U		•	•
	Demonstrate the working principle of tank pressure relief valves and the importance of maintaining the fuel tank pressure below the setpoint of the pressure relief valves for the fuel tanks.	A		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
2.4.3	Demonstrate how to safely isolate and replace a faulty pressure relief valve.	A			•
2.4.4	Describe various types of systems and equipment used for maintaining fuel storage condition by means of controlling tank pressure and temperature.	U		•	•
2.4.5	Explain the risk regarding not sufficient maintenance of the fuel storage conditions and the need for redundancy.	U		•	•
2.4.6	Describe the purpose and function of a tank holding space.	U		•	•
2.5	*Pressure monitoring*				
2.5.1	Describe the systems and equipment used for monitoring and measuring pressure, including alarm management and trip logic	U		•	•
2.5.2	Explain the terms operating pressure, pressure alarm high (PAH) and pressure alarm low (PAL).	U		•	•
2.5.3	Interpret pressure readings.	A		•	•
2.5.4	Analyse possible failure causes and mechanisms to pressure relief/safety valves and related preventive and mitigating measures.	A		•	•
2.6	*Temperature monitoring*				
2.6.1	Describe the equipment used for temperature monitoring.	U		•	•
2.6.2	Interpret readings from temperature monitoring equipment.	A		•	•
2.6.3	Analyse possible failure causes and mechanisms to temperature monitoring systems and related preventive and mitigating measures.	A		•	•
2.7	*Level gauging systems*				
2.7.1	Explain principle and method of operation of various types of level gauging systems.	U		•	•
2.7.2	Explain the terms level alarm low (LAL) and level alarm high (LAH) and the risks associated with high and low tank levels.	U		•	•
2.7.3	Explain likely issues of the various level gauging systems.	U		•	•
2.7.4	Analyse readings from level gauging equipment and identify discrepancies.	A		•	•
2.7.5	Describe the systems/equipment used for overfilling protection.	U		•	•
2.7.6	Interpret readings from overfill protection equipment.	A		•	•

3.3.4 The fuel supply system

Table 3-3 Recommended competence requirements for handling the fuel supply system

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
3.1	*Fuel supply system*				
3.1.1	Explain, as applicable, the principal configuration, safety philosophy, working principle, functional requirements, and main components of a (dual) fuel supply system, from the containment system to the respective consumers. As a minimum, the following ammonia fuel supply systems should be considered: — Fuel supply to combustion engines consuming: — gaseous ammonia (low pressure pumps, filters, vaporizers, master fuel valve, double block and bleed valve arrangement, gas valve unit, drain pots, systems to prevent fuel condensation) — liquid ammonia (low pressure pumps, filters, vaporizers, high pressure pumps, fuel valve train, fuel return system, knock out drums) — Ammonia fuel supply to solid oxide fuel cells (SOFC's), (low pressure pumps, filters, vaporizers, master fuel valve, double block and bleed valve arrangement, gas valve unit, drain pots, systems to prevent fuel condensation). — Fuel supply to reformers (crackers) reforming ammonia to hydrogen-rich gas for use in proton-exchange membrane (PEM) fuel cells (low pressure pumps, filters, vaporizers, master fuel valve, double block and bleed valve arrangement, gas valve unit, drain pots, systems to prevent fuel condensation). — Fuel supply to boilers, gas turbines, etc.	U		•	•
3.1.2	Recognize, if applicable, that there may be a need for additional competence if the ammonia system is part of a system based on other substances, such as fuel system also using hydrogen for power generation or propulsion. This includes if there is any other equipment relevant for the substance, such as hydrogen piping.	U		•	•
3.1.3	Identify various safety devices fitted in fuel supply system from P&ID provided in vessel's drawings.	U		•	•
3.1.4	Demonstrate fuel change over procedure and the line-up of piping and equipment, if applicable.	A		•	•
3.1.5	Apply a proactive approach with regards to preventive maintenance, systematic inspection, testing and validation of safety devices fitted in the fuel supply system to always ensure proper functionality.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
3.2	*Fuel preparation room (FPR)*				
3.2.1	Describe the purpose and function of an FPR.	U	•	•	•
3.2.2	Describe typical equipment located in an FPR (pumps, compressors, vaporizers, etc.).	U		•	•
3.2.3	Recognize the risk of ammonia leakage in the FPR.	U		•	•
3.2.4	Describe the safe working procedure for entering and working in the FPR.	U		•	•
3.2.5	Describe credible leak scenarios for the fuel preparation room and the relevant safety barriers and measures to prevent, mitigate and control credible leak scenarios (detection, ventilation, purging, etc.).	U		•	•
3.3	*Piping*				
3.3.1	Describe the design principles and particular requirements for piping in fuel supply system applicable for ammonia in liquid vs gaseous state.	U		•	•
3.3.2	Understand the consequence of mechanical damage to piping systems from vessel operations, cargo operations, green seas, and any activity on board.	U	•	•	•
3.3.3	Describe the importance of preventing ammonia spreading to non-hazardous/non-toxic spaces and how leakages in the piping system may cause toxic exposure to humans, or damage to other structures due to low temperature.	U		•	•
3.3.4	Describe credible leak scenarios for the piping and define safety barriers and measures to prevent, mitigate and control credible leak scenarios.	U		•	•
3.4	*Valves and filters*				
3.4.1	Explain the design of valves and filters used in ammonia piping systems.	U		•	•
3.4.2	Explain the operability of remotely operated valves and fail to safe operation in case of loss of power.	K			•
3.5	*Gas isolation valves (double block and bleed arrangement)*				
3.5.1	Carry out routine tests on gas isolation valves / double block and bleed arrangement.	A			•
3.5.2	Interpret test results of gas isolation valves / double block and bleed arrangement and take necessary actions.	I			•
3.5.3	Interpret test results of gas isolation valves / double block and bleed arrangement and take necessary actions.	K			•
3.6	*Recognize high differential pressure (high pressure control valve)*				

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
3.6.1	Describe the different high-pressure pump types and pump configurations used in the ammonia fuel supply systems.	K			•
3.6.2	Explain operation of high-pressure pumps in liquid fuel supply systems.	U		•	•
3.6.3	Operate a high-pressure pump.	A			•
3.6.4	Monitor pump readings.	A			•
3.6.5	Perform the cooling down procedure (if applicable).	A			•
3.7	*Low-pressure pumps (if applicable)*				
3.7.1	Describe the different low-pressure pump types and pump configurations used in ammonia fuel supply systems.	K			•
3.7.2	Explain operation of low-pressure pumps in liquid and gaseous fuel supply systems.	U		•	•
3.7.3	Operate a low-pressure pump.	A			•
3.7.4	Monitor pump readings.	A			•
3.8	*In-tank pumps (atmospheric systems only if applicable)*				
3.8.1	Explain the setup and operation of in-tank pumps.	U		•	•
3.8.2	Recognize the critical importance of maintaining gas tight cable penetration.	K		•	•
3.8.3	Start up the in-tank pumps.	A			•
3.8.4	Interpret readings related to the operation of in-tank pumps.	I			•
3.9	*Warm up and heating system and vaporizers*				
3.9.1	Describe the water glycol intermediate circuit.	U		•	•
3.9.2	Explain the alarms, interlocks and readings related to water glycol intermediate circuit.	U		•	•
3.9.3	Recognize the link of the heating system with the engine cooling system, if applicable.	U		•	•
3.9.4	Describe 'overpressure protection' in relation to the heating system.	U			•
3.9.5	Explain the possible delay in discovering leaks of ammonia into a glycol heating circuit.	U			•
3.10	*Vaporizers*				
3.10.1	Explain the purpose, function, and operation of an ammonia vaporizer.	U		•	•
3.10.2	Describe how vaporizers are protected from freezing.	U			•
3.11	*Boil off gas system*				

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
3.11.1	Explain purpose, function, and operation of a reliquefaction system.	U		•	•
3.11.2	Explain the purpose, function, and operation of thermal oxidation systems, such as GCUs and boilers.	U		•	•
3.11.3	Describe purpose, function, and operation of a subcooling system.	U		•	•
3.11.4	Explain pressure accumulation and the limitations of this passive boil off gas handling method.	U		•	•
3.12	*Cracker and/or reformer (if applicable)*				
3.12.1	Describe the purpose, function, and operation of a cracker and/or reformer system.	U		•	•
3.13	*Exhaust system*				
3.13.1	Explain the dangers of residual ammonia in the exhaust system.	U		•	•
3.13.2	Describe the burst disc/explosion venting system.	U		•	•
3.13.3	Describe the selective catalytic reduction (SCR) system.	U		•	•
3.13.4	Interpret handling of SCR catalysts.	A		•	•
3.13.5	Interpret the operation and function of burst disk systems and safety valves.	I			•
3.14	*Bilge and drainage systems*				
3.14.1	Describe typical bilge and drainage systems and how they can be affected by ammonia/ammonia hydroxide.	K			•
3.14.2	Explain the functionality and operability of the drain pumps or ejectors.	K			•
3.14.3	Explain the risk associated with liquid ammonia exposed to liquid water in bilge systems.	U	•	•	•
3.14.4	Explain need for segregating bilge systems in ammonia spaces from bilge systems in gas safe spaces.	U	•	•	•
3.15	*Systems to prevent condensation of gaseous ammonia*				
3.15.1	Explain the risk associated with liquid ammonia entering various consumers.	U	•	•	•
3.15.2	Explain the term dew point and how it is affected by temperature, pressure, and water content of the ammonia fuel.	U		•	•
3.15.3	Explain how the risk of ammonia condensation in gaseous fuel supply systems is mitigated, e.g. heat tracing, pressure, and pipe wall temperature monitoring, dynamic or static dew point calculation, drain pots, limit switches, ESD (emergency shutdown).	U		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
3.15.4	Explain the possible accumulation of water in the drain pot and how to safely remove water from the drain pot.	U		•	•
3.15.5	Explain how liquid ammonia/ammonia hydroxide may be safely removed from drain pot.	U		•	•

3.3.5 Venting and ventilation

Table 3-4 Recommended competence requirements for venting and ventilation

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
4 .1	*Importance of mechanical ventilation of confined/semi-confined spaces*				
4.1.1	Explain the importance of a functioning ventilation system to ensure safe operation of an ammonia fuel system.	U	•	•	•
4.1.2	Explain the importance and the function of air locks.	U	•	•	•
4.1.3	Explain the use of positive pressure and negative pressure at various places in the system, i.e. toxic spaces, air locks and safe haven.	U		•	•
4.1.4	Explain the importance of relative negative pressure in hazardous and toxic areas in relation to gas safe areas.	U		•	•
4.1.5	Verify proper functionality and perform calibration/check of instrumentation in pressure monitoring system to ensure correct positive pressure and negative pressure conditions.	A			•
4.1.6	Adjust differential pressure switches when needed.	A			•
4.1.7	Explain the difference between normal ventilation and catastrophe ventilation.	U		•	•
4.1.8	State the required ventilation capacity (air-changes per hour) for relevant spaces according to regulations.	U		•	•
4.1.9	Recognize the risks and safeguards to avoid toxic gases released in a space are spread to other spaces via the ventilation system.	K		•	•
4.1.10	Explain the requirements for redundancy in ventilation capacity after an active fan component failure or a failure in the power supply system to the fans.	U		•	•
4 .2	*Fuel gas venting system*				

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
4.2.1	Explain typical sources and scenarios for normal and emergency operations and venting, e.g. purging operations, bleeding operations, pressure relief from fuel supply system due to trapped liquids, pressure relief from fuel containment system.	U		•	•
4.2.2	List systems that utilize/connect to the pressure relief system, including (but not limited to) fuel tank, interbarrier spaces, tank connection spaces, etc.	U		•	•
4.2.3	Explain why fuel vents in normal operation are required to be directed to an ammonia release mitigation system, and explain the maximum allowable normal operation toxic discharge concentration at the outlet of the vent mast.	U		•	•
4.2.4	Explain why fuel vents in an emergency are allowed to be directly vented to the atmosphere, the expected toxic concentrations in relevant locations of the vessel and what safety actions may be taken during emergency venting.	U		•	•
4.2.5	Monitor vent piping and discharge system for toxic atmosphere.	A			•
4.2.6	Describe the engine crankcase venting system.	U		•	•
4.2.7	Describe the venting of double wall pipe annular spaces, if applicable.	U			•
4.2.8	Describe the venting of bunkering systems, including venting of vapours and through PSVs.	U			•

3.3.6 Technical safety barriers

Table 3-5 Recommended competence requirements for technical safety barriers

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
5.1	*Leak detection systems*				
5.1.1	Describe the gas detection system on board and other possible means of ammonia leak detection, as applicable.	U	•	•	•
5.1.2	Interpret false readings on gas detection systems on board and how redundancy is built in leak detection system.	A	•	•	•
5.1.3	Maintain an adequate inventory of spare parts to ensure required availability of the leak detection systems.	A			•
5.1.4	Demonstrate the operation of the interlocks as part of the leak detection and gas control system.	A	•	•	•
5.1.5	Carry out calibration of the leak detection system.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
5.1.6	Perform maintenance on the leak detection system.	I			•
5.2	*Control, monitoring and safety systems*				
5.2.1	Describe the main functional requirements of the control, monitoring and safety systems, including (but not limited to) safe and reliable operation, leak detection, close down the fuel supply system upon fault conditions which may develop too fast for manual intervention, maintain propulsion, restoring propulsion power, avoid spurious shutdowns of the fuel supply system, etc.	A		•	•
5.2.2	Interpret readings from the process control system. Proactively monitor the system status and recognize and act upon expected deviations and unexpected variations. Utilize the related features in the control and monitoring system and recognize its limitations.	I			•
5.2.3	Carry out fault-finding related to the control and alarm board.	A			•
5.2.4	Carry out troubleshooting related to the control and alarm board.	A			•
5.2.5	Interpret the difference and need for independence between control, monitoring, and safety systems.	I			•
5.2.6	Describe the testing requirements and intervals of the control, monitoring and safety systems, as required by regulations/ rules.	A			•
5.3	*Emergency shutdown system*				
5.3.1	Describe the consequences of activating an ESD call button.	U	•	•	•
5.3.2	Identify locations of the manual shutdown push buttons on board, as means of manual emergency shutdown.	K	•	•	•
5.3.3	Explain the operation, alarms, and triggers of the emergency shutdown system.	U		•	•
5.3.4	Explain the emergency shutdown sequence, including the manual tasks to be performed upon the activation of ESD.	U		•	•
5.3.5	Perform emergency shutdown tests.	A			•
5.3.6	Interpret a cause-and-effect diagram.	A		•	•
5.4	*Safety relief valves*				
5.4.1	Explain the need for safety relief valves in liquid and gaseous ammonia piping and equipment.	U	•	•	•
5.4.2	Explain the working principle of safety relief valves.	U		•	•
5.4.3	Carry out the emergency closing procedure of safety relief valves.	A			•
5.5	*Spray shielding*				

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
5.5.1	Explain the purpose of spray shielding fitted to potential leakage points in the ammonia fuel system.	U			•
5.5.2	Describe different types of spray shielding that may be applied.	U	•	•	•
5.6	*Drip trays*				
5.6.1	Explain the purpose and function of drip trays fitted below potential leakage points in the ammonia fuel system and the principles of draining, containing or evaporation of leaks as applicable.	U	•	•	•
5 .7	*Portable gas detection equipment*				
5.7.1	Explain purpose and principles of operation of different portable gas detection instruments.	U	•	•	•
5.7.2	Calibrate, verify, and use portable gas detection equipment (oxygen, ammonia).	I			•
5.8	*Fire detection and extinguishing system*				
5.8.1	Describe the relevant components of the fire detection system.	U	•	•	•
5.8.2	Describe the relevant components and functionality of the compatible fire extinguishing system, e.g. the dry chemical power system, water mist systems, fixed gas fire-extinguishing systems and low-expansion foam.	U		•	•
5.8.3	Operate the fire-fighting system relevant for the ammonia fuel system on board.	A		•	•
5.8.4	Explain the dangers of using non-compatible fire extinguishing systems.	U		•	•
5.9	*Certified safe electrical equipment*				
5.9.1	Describe locations where EX-proof lighting and equipment is required.	U		•	•
5.9.2	Interpret a wiring diagram of an EX-certified instrument.	U	•	•	•
5.9.3	Connect a motor in EX-mode.	I			•
5.9.4	Replace EX-barriers in I/O modules.	I			•
5.9.5	Maintain inventory of EX-certified spare parts, based on the criticality in relation to ammonia related components.	U		•	•
5.10	*Double-walled piping*				
5.10.1	Explain the importance and purpose of double-walled piping.	U	•	•	•
5.10.2	Explain the various configurations of double-walled piping annular space (ventilated, unventilated, inerted, vacuum).	U	•	•	•
5.10.3	Perform inspection and leak tests on double-walled piping.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
5.10.4	Describe how to handle double-walled piping during dis-assembling and re-assembling.	U			•
5.11	*Space specific safety barriers*				
5.11.1	Demonstrate the technical safety barriers, and their function, inside the TCS, including leakage detection, ventilation system to dilute and discharge ammonia vapours to open air, mechanical shielding of leak points and isolation of leak.	A		•	•
5.11.2	Explain technical safety barriers implemented in a fuel preparation room.	A		•	•
5.11.3	Explain technical safety barriers implemented in a bunkering station.	A		•	•
5.12	*Ammonia release mitigation system (ARMS)*				
5.12.1	Explain the purpose, working principle, and operation, of the vessel specific ARMS. Examples of ARMS: — gas combustion unit — scrubber system — water seal system — nitrogen/air dilution system.	U		•	•
5.12.2	Operate the vessel specific ARMS.	A		•	•
5.12.3	Carry out disposal of, and change, effluents from ARMS.	A		•	•
5.12.4	Illustrate the importance of leading ARMS discharges to the vent mast in case of ARMS functional failure.	A			•
5.12.5	Describe possible failure causes and mechanisms of ARMS and related preventive and mitigating measures.	U		•	•
5.13	*Water safety systems*				
5.13.1	Describe the purpose and functionality of onboard water safety systems for the ammonia fuel system and spaces in which the system is located. This includes, but is not limited to: — water spray or mist systems — water curtains and screens — decontamination showers and eye wash station.	U	•	•	•
5.13.2	Explain the risk of operating water safety systems in vicinity of liquid ammonia leakages.	U		•	•
5.13.3	Practice the defined operational assumptions for the vessel in all ambient conditions, e.g. the need for heating if water supply piping is exposed to freezing conditions.	A		•	•
5.13.4	Describe principles for containment and disposal of ammonium hydroxide at port, at sea and associated restrictions related to MARPOL convention, if applicable.	I		•	•

3.3.7 Auxiliary systems

Table 3-6 Recommended competence requirements for auxiliary systems

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
6 .1	*Inert gas generator (if applicable)*				
6.1.1	Define principles of operation of an inert gas generator.	U		•	•
6.1.2	Define 'inert gas' and its requirements.	U		•	•
6.1.3	Explain the impact of inert gas on ammonia held within the system (water hammer).	U		•	•
6.1.4	Operate an inert gas generator to supply dry air of appropriate quality.	A			•
6 .2	*Nitrogen generation and distribution (if applicable)*				
6.2.1	Define principles of operation of a nitrogen generator.	U		•	•
6.2.2	Explain how the nitrogen injection and purging arrangement works.	U		•	•
6.2.3	Explain when the nitrogen injection and purging arrangement should be operational.	U		•	•
6.2.4	State the maximum allowable percentage of oxygen in the mix.	K		•	•
6.2.5	Describe nitrogen outlet requirements.	U		•	•
6.2.6	Operate the nitrogen generator.	A			•
6.2.7	Operate the air compressor used for nitrogen generation and distribution.	A			•
6.2.8	Operate the booster compressor.	A			•
6.2.9	Take appropriate action in case of nitrogen quality problems.	A			•
6 .3	*Air and inert gas dryers (if applicable)*				
6.3.1	Explain the purpose and operating principles of air and inert gas dryers.	U		•	•
6.3.2	Describe the tank conditioning method 'drying' and its importance.	U		•	•
6.3.3	Describe the tank conditioning method 'inerting' and its importance.	U		•	•
6.3.4	Operate the air and inert gas dryer.	A			•
6 .4	*Control/instrument air*				
6.4.1	State important checks in determining the quality of control/ instrument air.	A			•

3.3.8 Bunkering activities

Table 3-7 Recommended competence requirements for bunkering activities

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
7 .1	*Bunkering preparations*				
7.1.1	Describe the tasks and responsibilities of both crew and bunkering personnel during preparations.	K	•	•	•
7.1.2	Determine the condition of the fuel containment system (pressure and temperature).	A		•	•
7.1.3	Agree pre-bunkering formalities and operational alignment between vessel and bunker operator in line with port regulations, e.g. pre-bunkering/compatibility checklist, communication lines.	A		•	•
7.1.4	Interpret ammonia certificate, understand quality requirements, run sampling procedure (if applicable) and state the allowable/targeted fuel temperature for bunkering.	A		•	•
7.1.5	Describe state the start-up and ramp-up rates until full transfer rate, and ramp-down rates at completion of bunkering.	U		•	•
7.1.6	Demonstrate correct and clear communication during bunkering process.	A		•	•
7.1.7	Agree emergency actions in combination with bunker provider in case of emergencies.	A		•	•
7.1.8	Determine the vapour handling capacities of bunker provider and own vessel.	A		•	•
7.1.9	Determine the pressure levels of the nitrogen system to ensure adequate supply for the bunkering operation.	A		•	•
7.1.10	State the acceptable pump rates during the bunker transfer.	U		•	•
7.1.11	State the importance of and the determining factors for using the vapour return system (if applicable).	U		•	•
7.1.12	Determine tank sequence for bunkering (if applicable).	A		•	•
7.1.13	Explain the risk associated with buildup of static electricity during the bunkering process and the preventive measures required to avoid hazardous events in that respect.	U		•	•
7.1.14	Describe measures taken onboard to ensure proper grounding and static discharge during operations.	U		•	•
7.1.15	Explain the need for inerting of the filling lines prior to the bunker transfer.	U		•	•
7.1.16	Explain the need for purging of the filling lines prior to the bunker transfer.	U		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
7.1.17	Explain the procedure for the ESD valve test prior to bunkering.	U			•
7.1.18	Interpret the importance of connection of ESD link vessel-to-vessel or shore-to-vessel and testing of the entire control loop prior to bunkering.	A		•	•
7.1.19	Understand the importance of cooling down liquid lines before bunkering.	U		•	•
7.1.20	Explain how to perform pre-cooling of bunkering lines prior to bunkering (if applicable).	U		•	•
7.1.21	Run cool down procedure for lines and tanks (if applicable).	A			•
7.1.22	Describe methods for managing vapours from cooling down.	U		•	•
7.1.23	Perform leak test prior to bunkering.	A			•
7.1.24	Explain the procedure for coupling the bunkering hose.	U			•
7.1.25	Demonstrate the purpose and function of a loading arm.	A			•
7.1.26	Explain the importance of drip-trays being kept free of (rain or condensate) water before commencing bunkering.	U		•	•
7.1.27	Verify drip-tray drains are closed prior to ammonia service.	U		•	•
7.1.28	Verify fendering does not interfere with the bunker transfer arrangement and hose saddles.	A		•	•
7.2	*Bunker transfer*				
7.2.1	Explain restrictions during bunkering operations, i.e. other types of operations, lifting, SIMOPS and personnel transfer.	U	•	•	•
7.2.2	Describe the process for bunkering operations, including filling of bunker lines, filling limit and loading limit of fuel tanks.	U		•	•
7.2.3	Explain start and stop sequences and monitoring procedures during bunker transfer.	U		•	•
7.2.4	Interpret readings from the bunker control system, including but not limited to alarms and system functionalities related to bunkering (e.g. High vs. High-High) and implement necessary actions.	A		•	•
7.2.5	Explain the functionality of the main components in the fuel bunkering system and operate valves for distribution in accordance with planned filling sequence.	A			•
7.2.6	Explain what happens on board receiving vessel during bunkering in the event an ESD is triggered.	U		•	•
7.3	*Post bunkering*				
7.3.1	Demonstrate the bunkering stopping procedure.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
7.3.2	Explain the purpose and procedure for emptying and inerting of the vapour return hose, including use of onboard ARMS.	U		•	•
7.3.3	Explain the purpose and procedure for inerting of the ammonia bunkering pipe from manifold to the tank, including use of onboard ARMS.	U		•	•
7.3.4	Recognize the possibilities of residual ammonia in the bunkering equipment.	U		•	•
7.3.5	Check the composition of the bunkering arrangement, e.g. liquid residuals and quality of performed purging operation, i.e. oxygen, toxic concentration inside the hose.	I			•
7.4	*Bunker calculations*				
7.4.1	Explain the procedure of calculating ammonia bunker quantity, including shipboard system for volumetric measurements.	U		•	•
7.4.2	Verify bunker quantity received.	A		•	•
7.4.3	Describe procedures for how to take fuel samples, if applicable.	U		•	•
7.5	*Shore connections / emergency release / dry breakaway*				
7.5.1	Describe the significance of ensuring compatibility between the onboard bunkering setup of the receiving unit and the delivering unit, including connections, hoses, interfaces, ammonia transfer system, and safety systems.	U		•	•
7.5.2	Explain the need for safe disconnection of equipment in case of abnormal situation, such as weather change, lightning, drifting or other external factors.	U		•	•
7.5.3	Describe the potential risks related to emergency release / dry breakaway couplings.	U	•	•	•
7.5.4	Explain type and arrangement of shore connection arms (if applicable).	U		•	•
7.5.5	Explain the function of mooring systems to avoid drift away.	U		•	•
7.5.6	Explain the function of emergency release coupling or dry breakaway couplings.	U		•	•
7.5.7	Explain the use of flexible hoses.	U		•	•
7.5.8	Explain emergency breakout operation of shore connection arms and vessel-to-vessel bunkering (if applicable).	U		•	•
7.5.9	Explain emergency breakout operation of flexible hoses.	U		•	•
7.5.10	Estimate the required free space and trajectory for the bunkering arrangement.	A		•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
7.5.11	Recognize the movement limitations of the bunkering arrangement and equipment, e.g. hoses.	U		•	•

3.3.9 Tank conditioning

Table 3-8 Recommended competence requirements for tank conditioning

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
8.1	*Emptying tank*				
8.1.1	Explain the procedure of emptying the tank completely.	A			•
8.1.2	Explain the possibility for unpumpable liquids left in the tank, e.g. residuals of liquids in spaces out of reach of the pump.	A			•
8.2	*Warming up*				
8.2.1	Describe the resources, infrastructure, and local conditions required for warming up tanks.	U		•	•
8.2.2	Calculate the approximate duration of warming up.	A		•	•
8.2.3	Perform warming up procedure, keeping the tank atmosphere in a non-explosive range at all times.	A			•
8.3	*Gas freeing*				
8.3.1	Describe principles and physics involved in the changing of tank atmospheres.	U		•	•
8.3.2	Describe the resources, infrastructure and local conditions required for gas-freeing.	U		•	•
8.3.3	Explain likely behaviour of vapour pressure during gas freeing.	U		•	•
8.3.4	Calculate the approximate duration of gas freeing.	A			•
8.3.5	Perform gas freeing, keeping the tank atmosphere in a non-explosive range at all times.	A			•
8.4	*Inerting*				
8.4.1	Explain the principle of inerting.	U	•	•	•
8.4.2	Explain possible problems related to inerting and causes, such as condensate formation.	U		•	•
8.4.3	Describe dangers associated with incorrect inerting procedure.	U		•	•
8.4.4	Make a plan for inerting tanks, pipelines, and equipment.	I			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
8.4.5	Determine when the inerting operation is completed based on parameters.	A			•
8.4.6	Determine oxygen content.	A			•
8.4.7	Perform a controlled change in tank atmosphere through inerting.	A			•
8.5	*Purging*				
8.5.1	Explain the principle of air purging.	U	•	•	•
8.5.2	Demonstrate line up and procedures to purge tanks and pipelines.	A			•
8.5.3	Perform gas freeing.	A			•
8.5.4	Perform nitrogen purging.	A			•
8.5.5	Determine when nitrogen purging operation is completed, based on parameters.	A			•

3.3.10 Maintenance

Table 3-9 Recommended competence requirements for maintenance

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
9 .1	*Risk assessment and maintenance preparations*				
9.1.1	Evaluate the need for type-specific training considering maintenance on ammonia fuel supply systems and connected equipment / systems.	I		•	•
9.1.2	Practice the pre-defined boundaries of the maintenance that can be conducted by on board personnel, i.e. independently of external service personnel.	A		•	•
9.1.3	Interpret procedures for risk assessment considering maintenance, e.g. safe job analysis and permit to work.	I		•	•
9.1.4	Demonstrate knowledge about the specific technology used for ammonia monitoring and the system limitations, e.g. uncertainty in ammonia detection systems.	A		•	•
9.1.5	Demonstrate the various methods for detection of an ammonia leakage and explain the principal functionality of electrochemical gas detectors.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
9.1.6	Demonstrate overall system knowledge and understanding of system boundaries, how different systems and subsystems are connected to each other and can influence each other, directly and indirectly, when work is performed on parts of the system.	I		•	•
9.1.7	Demonstrate precautionary measures and procedures to be taken into account considering maintenance of systems that may contain ammonia or that are connected to systems that contain ammonia. Note that experience indicate that adjacent systems can contain residuals of ammonia, e.g. in lube oil system, crank case and crankcase ventilation system, cooling water system, and similar.	A		•	•
9.1.8	Recognize the importance of proper preparations, communication with crew members across various disciplines, lockout-tagout (LOTO) procedures and state work permit procedures prior to commencing maintenance activities.	I		•	•
9.1.9	Analyse the specific maintenance preparation procedures, as described by e.g. maker or manufacturer.	A			•
9.1.10	Analyse the necessity and potential dangers for maintenance on several systems simultaneously, where minimum one is part of the ammonia fuel system.	I			•
9.1.11	Understand the need for and purpose of additional maintenance activities for ammonia fuel systems compared to conventional fuel systems.	A			•
9.1.12	Explain the importance of using compatible materials in piping and equipment.	U		•	•
9.1.13	Explain why improvised solutions using non-standard parts are dangerous and not to be used.	U		•	•
9.1.14	Describe ammonia specific material degradation mechanisms and the way to detect those.	U		•	•
9.1.15	Knowledge about maintenance to be performed by external service provider.	U		•	•
9.1.16	Crew must be able to explain the vessel specific hazards for service /external maintenance personnel.	U		•	•
9.1.17	Describe the entry procedure relevant for hazardous spaces, such as tank connection space and fuel preparation room.	A		•	•
9.1.18	Demonstrate the procedures and equipment to be used in the regular preventive maintenance.	A			•
9.1.19	Interpret the purging and gas-freeing procedure of the ammonia fuel system prior to maintenance execution.	I			•
9 .2	*Maintenance communication procedures*				

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
9.2.1	Demonstrate the communication and alarm procedures and requirements before, during and after maintenance, to provide feedback on the actual and current status of the systems related to ammonia.	A	•	•	•
9.2.2	Demonstrate the communication procedures in case of an ammonia leakage during maintenance.	A		•	•
9.2.3	Recognize communication needs and give status from equipment monitoring system.	A		•	•
9 .3	*Conducting maintenance*				
9.3.1	Analyse the process of maintenance operation in order to assess and determine if the operation should be paused/ aborted, and communicate monitoring equipment readings on regular basis during maintenance operation.	I		•	•
9.3.2	Assess the integrity, safety, and operational status of the PPE and gas detector systems.	I		•	•
9.3.3	Analyse and assess the status and degradation of system and equipment, in particular ammonia specific material degradation mechanisms, considering, but not limited to: — corrosion — corrosion under isolation (CUI) — vibration and stress — fatigue.	I			•
9.3.4	Analyse the hazards and necessity of performing troubleshooting inside the TCS while the ammonia fuel system is operational. NOTE: For trained service personnel only! Consult maker / manufacturers specific procedures.	I			•
9.3.5	Carry out proper and sufficient inspection of ammonia system, considering, but not limited to: — double walled piping system — transfer hoses — tanks — valves — welding points — pressure safety valves — burst disk — insulation (if applicable).	A			•
9.3.6	Perform the maintenance of gas detectors and safety instrument system, e.g., ESD system.	A			•
9.3.7	Carry out draining of residual water in piping system (condensed water) of the ammonia fuel system.	A			•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
9.3.8	Perform maintenance on the water safety system, e.g.: — water spray and mist systems — water curtains and water screens — eye wash station and decontamination showers.	A			•
9.3.9	Perform maintenance on the ARMS.	A			•
9.3.10	Perform inspections, tests, and routine calibration of pressure monitoring equipment.	I			•
9.3.11	Perform checks and maintenance on: — pressure controllers — pressure transmitters — pressure and safety relief valves.	A			•
9.3.12	Perform inspections, tests, and routine calibration of: — temperature monitoring equipment for tank structure — temperature monitoring equipment for liquid and vapour in the tank — temperature transmitters — temperature alarms.	A			•
9.3.13	Perform inspections, tests and routine calibration of: — tank level monitoring equipment — level transmitters — level alarms.	A			•
9.3.14	Perform inspection and maintenance on ESD-valves.	A			•
9.3.15	Perform inspection, maintenance, and repair of EX-certified equipment.	A			•
9.3.16	Perform maintenance on double-walled piping.	A			•
9.3.17	Perform maintenance on — the nitrogen generator — the air compressor used for nitrogen generation and distribution — the booster compressor — the air and inert gas dryer.	A			•
9.3.18	Perform maintenance on a high-pressure pump.	A			•
9.3.19	Perform maintenance on the cracker / reformer system.	A			•
9.3.20	Explain where to return the vapours during gas freeing and warming up.	U		•	•
9 .4	*Maintenance completion*				
9.4.1	Interpret the importance of post maintenance carefulness, such as keeping a safe distance to hazardous and toxic areas when starting up systems after maintenance.	I	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
9.4.2	Explain the possibility of residuals/traces of ammonia on PPE upon completion, and how to handle contaminated PPE.	I	•	•	•
9.4.3	Interpret the importance of gas integrity of the ammonia system and organize the testing of the system (functionality and gas tight integrity) according to maker/manufacturers procedures.	I			•
9.4.4	Analyse the occurrence and root cause of leaks due to maintenance errors.	I			•
9.4.5	Assess if the system is to be shut down / purged accordingly in case of a leak or mishap.	I			•
9.4.6	Demonstrate the planned and approved start-up procedure after completion of maintenance.	I			•

3.3.11 Emergencies and contingencies

Table 3-10 Recommended competence requirements for emergencies and contingencies

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
10.1	*General*				
10.1.1	Describe the different credible critical scenarios and emergencies which can occur, by using e.g. credible risk scenarios as per HAZID results, or other risk assessments.	U	•	•	•
10.1.2	Describe risk scenarios caused by adjacent emergencies, such as impact on ammonia piping/storage from lube oil fire.	U	•	•	•
10.1.3	Describe the different emergency alarm system related to potential ammonia emergencies.	U	•	•	•
10.1.4	Describe visibility restrictions caused by dense clouding from released anhydrous ammonia.	U	•	•	•
10.1.5	In case of an emergency, act upon defined contingency plans, including use of escape routes and lifesaving appliances.	A	•	•	•
10.1.6	Demonstrate the correct use of escape equipment in an emergency or abandon vessel situation.	A	•	•	•
10.1.7	Determine the safest position on board (e.g. safe haven) in case of an ammonia release, emergency discharge or spill, based on the current location of the personnel.	I	•	•	•
10.1.8	Demonstrate the integrity and functional status of the PPE and gas detector systems specific for emergencies.	A	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
10.1.9	Demonstrate the correct use of PPE and escape equipment required to respond to an ammonia leak.	A	•	•	•
10.1.10	Demonstrate the use of eye wash stations and first aid response (e.g. oxygen resuscitation equipment and stretcher) related to ammonia.	U	•	•	•
10.1.11	Demonstrate use of decontamination showers.	U	•	•	•
10.1.12	Interpret the potential hazards affecting lifeboats.	A		•	•
10.1.13	Organize and conduct relevant safety training and drills defined in the vessel's emergency response plan, taking into account various ammonia leakage scenarios, including specific situations such as: — different wind directions, based on gas dispersion analysis — different locations onboard, both open deck and confined spaces.	I		•	•
10.1.14	Explain scenarios where ammonia may be close to sea surface in an abandon vessel situation, e.g. large ammonia spills to the sea during bunkering.	A		•	
10.1.15	Determine the most suitable vessel position / vessel orientation considering environmental conditions (e.g. wind direction) and proximity to nearby infrastructure/stakeholders (such as vessels, port, oil rig, etc.) in case of an ammonia incident.	I		•	
10.2	*Ammonia liquid leaks*				
10.2.1	Explain the hazards associated with ammonia liquid leaks.	U	•	•	•
10.2.2	Describe the emergency response strategies to mitigate consequences associated with ammonia liquid leaks, including the distinction between emergency responders and the rest of the crew.	I		•	•
10.2.3	Understand ammonia toxicity impact on marine life considering spill to sea.	K	•	•	•
10.3	*Ammonia gaseous leaks*				
10.3.1	Recognize indications of an ammonia gaseous leak and interpret how to act accordingly.	U	•	•	•
10.3.2	Execute appropriate action in accordance with established procedures in case of a detected gas leak.	A	•	•	•
10.3.3	Demonstrate the methods to locate a gas leak.	A		•	•
10.4	*Ammonia fire*				
10.4.1	Describe the credible fire scenarios of ammonia.	K	•	•	•
10.4.2	Explain the potential danger of trying to extinguish a fire prior to stopping a leak.	U	•	•	•

ID	Competence activity 'The crew on an ammonia-fuelled vessel shall be able to...'	Required level of cognition	Category A All	Category B Deck	Category C Engine
10.4.3	Describe the extinguishing agents and the designated firefighting systems for credible ammonia fires on board.	U	•	•	•
10.4.4	Demonstrate the methods for extinguishing an ammonia fire.	A		•	•
10.4.5	Explain the ESD sequence considering the fire detection.	U		•	•
10.5	*Emergency stop and emergency shutdown (ESD)*				
10.5.1	Demonstrate and explain different emergency stop procedures for ammonia fuel supply system and processes, e.g. the use and consequence of emergency stop buttons.	A		•	•
10.5.2	Understand vessel defined ESD philosophy, including ESD levels and designated systems.	U		•	•
10.5.3	Interpret the effects of activating the emergency stop for the engine, as there may be ammonia left in the system.	I		•	•
10.5.4	Interpret the functionality of the ESD system.	I		•	•
10.5.5	Describe and demonstrate that the ESD sequence is successfully conducted and describe the fail-safe criteria for relevant equipment.	I			•
10.5.6	Explain what can cause an ESD scenario.	U		•	•
10.5.7	Perform an emergency shutdown.	A		•	•
10.5.8	Describe the effects on the ammonia fuel system in case of a blackout on board the vessel, e.g. traces/residuals of ammonia in system as result of an unexpected shutdown.	I			•
10.5.9	Interpret the process for the systems that will start in safe-mode when recovering from dead vessel.	I			•
10.5.10	Execute the dead vessel recovery procedure.	A			•
10.6	*Emergency communication*				
10.6.1	Demonstrate proper communication procedures in case of emergency ammonia hazards, in accordance with vessel contingency plan.	A		•	•
10.6.2	Interpret additional information which needs to be communicated to authorities and relevant stakeholders in case of an unexpected large-scale spill/leak.	I		•	•
10.7	*Emergency unloading/transfer of ammonia*				
10.7.1	Describe the possibilities for emergency unloading or transfer of ammonia.	U		•	•
10.7.2	Perform the procedure for transferring ammonia to another vessel in case of an emergency.	A		•	•
10.8	*Emergency discharge*				
10.8.1	List principles of emergency discharge.	K	•	•	•

ID	*Competence activity* *'The crew on an ammonia-fuelled vessel shall be able to...'*	*Required level of cognition*	*Category A* *All*	*Category B* *Deck*	*Category C* *Engine*
10.8.2	Explain the procedure and points of attention related to an emergency release of ammonia.	A		•	•
10.8.3	Interpret the consequences from emergency unloading of ammonia.	I		•	•
10.9	*Emergency separation*				
10.9.1	Describe criteria/situations which would trigger emergency separation.	U		•	•
10.9.2	Find the local port requirements on emergency separation.	A		•	•
10.9.3	Explain the steps involved in emergency separation during bunkering.	U		•	•

CHANGES – HISTORIC

There are currently no historical changes for this document.

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