INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON CARRIAGE OF CARGOES AND CONTAINERS
9th session
Agenda item 3

CCC 9/INF.16
11 July 2023
ENGLISH ONLY
Pre-session public release: ☒

AMENDMENTS TO THE IGF CODE AND DEVELOPMENT OF GUIDELINES FOR ALTERNATIVE FUELS AND RELATED TECHNOLOGIES

Gap analysis between ammonia as fuel and the IGF Code

Submitted by IACS

SUMMARY

Executive summary:	This document provides information on gap analysis between ammonia as fuel and the IGF Code for LNG, taking into account the different properties, behaviours and hazards/risks.
Strategic direction, if applicable:	2
Output:	2.3
Action to be taken:	Paragraph 43
Related documents:	MSC 105/20 and CCC 8/18

Background

1 The Maritime Safety Committee, at its 105th session, agreed to include in the biennial agenda of the Sub-Committee on Carriage of Cargoes and Containers (CCC) for 2022-2023 and the provisional agenda for CCC 8 an output on "Development of guidelines for the safety of ships using ammonia as fuel", with a target completion year of 2023 (MSC 105/20, paragraph 18.26).

2 MSC 106 changed the description of this output in order to accommodate the consideration of alternative fuels not having a low flashpoint. This resulted in the deletion of output 2.24 on "Development of guidelines for the safety of ships using ammonia as fuel" to avoid duplication.

3 In CCC 8, the Sub-Committee agreed to re-establish the Correspondence Group on the Development of Technical Provisions for Safety of Ships using Alternative Fuels, under the coordination of Germany, and instructed it to develop interim guidelines for the safety of ships using ammonia as fuel, taking into account documents CCC 8/13, CCC 8/13/1, CCC 8/13/2 and annex 3 to document CCC 8/WP.3, and submit a written report to CCC 9 (CCC 8/18, paragraph 3.24).

Introduction

4 IACS participated in the Correspondence Group and is grateful to the coordinator and to all who have contributed to progressing the work. Additionally, IACS has performed a gap analysis to identify clauses of the IGF Code, which would be relevant to the use of ammonia as fuel, and to determine whether new requirements would be necessary.

5 With a view to facilitating further discussions on this topic, this document provides information on gap analysis between ammonia as fuel and the IGF Code for LNG as fuel, taking into account the different properties, behaviors, and hazards/risks. At the same time, the corresponding suggestions to fill the gaps have been proposed as a study on the gaps between ammonia and LNG (see annex).

Discussion – outcome of the gap analysis

6 Because ammonia is not a low-flashpoint fuel, the term "low-flashpoint fuel" stated in the Preamble of the IGF Code should be revised to read "gases and low-flashpoint fuel", in order to cover ammonia within this Code. Amendments are also required in SOLAS, title of the IGF Code (and other locations), and specifically SOLAS definitions of the "IGF Code", "Low- flashpoint fuel"; application of the IGF Code could be amended as "International Code of Safety for Ships Using Gases or Low-Flashpoint Fuels". However, it is also noted that the IGC Code does not allow toxic gases to be used as fuel, which means ammonia cannot be used as fuel on gas carriers at present.

7 The definition of "fuel" for ammonia needs to be given. In addition, it is suggested that ISO could be approached to develop standards for specifications of ammonia as a marine fuel.

8 The risk assessment of ammonia fuel should address all relevant hazards. The toxicity of ammonia is a health risk to individuals onboard, however, the flammability and explosivity hazards should also be considered.

9 Inherently safer designs and meaningful protection should be adopted for ammonia.

10 The ESD machinery space concept, as defined in the IGF Code, should not be accepted for ammonia owing to its severe toxicity in case of leakage by a single failure.

11 In case arrangements for overboard discharge are prohibited (except in emergency cases), dedicated holding tanks are to be arranged for ammonia solutions created for the safety measures of ammonia leakage, such as water spray system or ammonia treatment system. It can be discharged to reception facilities or overboard by proper treatment. Connections are to be provided for discharge to reception facilities. Arrangements for overboard discharge, where permitted, could also be considered.

12 A drip tray for ammonia bunkering on open deck should be designed to limit spread of ammonia vapour owing to its toxicity.

13 General requirements for high pressure storage tank should be specified since ammonia may be stored under high pressure and ambient temperature condition. The limitation of MARVS of type C tank should be modified accordingly.

14 Storage of ammonia fuel in gaseous form may not be considered.

15 Portable fuel tanks are suggested to be limited at the early stage, unless the risk posed by the toxicity of ammonia is adequately addressed.

16 The arrangement of the tank connection space (TCS) depends on the distance between the fuel tank on open deck and the unwanted locations (e.g. ventilation intakes, openings to enclosed spaces on vessel, mustering stations, etc).

17 The vent outlet(s) position of ammonia tank pressure relief system should be further investigated regarding the toxicology impact of a release. This can be addressed by requiring closed-loop fuel systems, as far as practicable, and by specifying limits of toxic areas/zones and requirements for gas dispersion analysis and risk assessment.

18 Combustion gases from ammonia fuel should not be used as inert gas for purging and gas-free applications since ammonia may react with carbon dioxide to form carbamate.

19 Requirements for pipes with design temperature below -110C is not relevant for ammonia fuel piping.

20 Requirements for material and limiting oxygen concentration in fuel tanks or dissolved oxygen content into ammonia liquid should be developed considering the corrosive property and the stress corrosion cracking property of ammonia. A text similar to paragraphs 17.12.1 to 17.12.7 of the IGC Code is suggested to be added.

21 Guidelines for the acceptance of non-standard materials should be developed, similarly to MSC.1/Circ.1622 on Guidelines for the acceptance of alternative metallic materials for cryogenic service in ships carrying liquefied gases in bulk and ships using gases or other low-flashpoint fuels.

22 There is a need for calculation of reasonably foreseeable leakage scenarios (e.g. PML) for ammonia. This is related to the arrangement of the vent mast and other vent outlets including ventilation (e.g. dispersion analysis), sizing of the drip trays, determining the emergency ventilation.

23 Measures should be developed to prevent the leakage of vapour during bunkering of ammonia owing to its toxicity, including but not limited to:

.1 activate the automating shutdown of the bunkering pump and isolating valve closing when leakage detected; and

.2 activate vapour processing (e.g. with water spray) when leakage detected. In addition, the entrance, air inlet and opening of accommodation spaces, service space, machinery space and control station facing the credible leakage sources (e.g. bunker station, vent mast, etc.) should be carefully arranged and ammonia vapor detector should be installed.

24 Owing to the toxicity of ammonia, gas from ammonia fuel supply system (AFSS), should not be directly discharged into the atmosphere during normal operation. Ammonia treatment systems (e.g. knock-out drum, gas absorber) or returning to fuel tank/holding tank are possible, however, are not the only options to implement this.

25 Unburnt ammonia emissions from internal combustion engine should not present a significant health hazard, so the limitation of ammonia concentration needs to be defined and methods of detecting ammonia leakage from possible leak points such as crankcase, sumps, cooling system, air intake and scavenge spaces and so on with applicable safety measures need to be developed.

26 Requirements for ammonia treatment system and tank holding ammonia effluent generated from ammonia treatment system should be developed. The requirements for the tank should include at least the capacity (based on permissible ammonia level for discharge to sea), vent, location, etc.

27 Use of water curtains may be considered for preventing ammonia leakage to outside areas, such as for the Fuel Preparation Room (FPR).

28 Toxic area zones around ammonia release source(s) including vent/bleed outlet should be defined for ammonia based on dispersion properties and permissible level of concentration. TWA (time-weighted average, 25 ppm, mild irritation, 8h/day, repeated exposure) may be considered as permissible level which does not present a significant health hazard. IDLH (immediately dangerous to life or health) values also need to be considered which may drive shutdown and additional required mitigation. The permissible exposure limit would apply in all locations where the crew members and passengers may be present.

29 Risk assessment for ammonia engines should be addressed; specific hazards to be considered may be defined by further discussion. For example, explosion relief fitted at exhaust system and unburned gas from exhaust system should be subject to additional consideration for toxicity.

30 At present, requirements for ammonia boilers may be considered for development, however, it is preferable not to include development of requirements concerning gas turbines using ammonia as fuel.

31 There is no clear information with reference to redundancy level of the ventilation in spaces containing ammonia, no clear actions in case of ventilation loss in the spaces containing ammonia, no details with reference to closing devices for all air intakes and other openings to accommodation, service spaces, control stations, and other manned spaces upon detection of ammonia in the IGF Code. It is hereby proposed to deal with the above issues for ammonia.

32 Consideration should be given to the activation of emergency ventilation in the engine room in case of worst-case leakage detected when there is significant health hazard from ammonia.

33 Temperature Class and Gas Group is not specified for electrical installations located in hazardous areas, which is recommended to be suitable for ammonia atmospheres and, at least, to meet the Temperature Class T1 and Gas Group IIA.

34 There is no clear statement on fail-safe principle for the safety system required in chapter 15 of the IGF Code, which is recommended to be fail safe for ammonia.

35 Requirements of gas detection limits, voting principles for gas detectors of ammonia should be developed. Standard practice in existing ammonia carriers can be taken into consideration for defining the limits. Permanently installed gas detectors are suggested to be installed in enclosed bunkering stations, air intakes for accommodation spaces, etc. Reference to IEC 45544 series of standards for gas detection system for ammonia is recommended.

36 For requirements concerning welding and post-weld heat treatment, paragraphs 17.12.3 to 17.12.3.5 of the IGC Code may be considered. Some proposals for this are given in the annex to this document.

37 Extending the scope of paragraph 16.7.1 (Type testing of valves) of the IGF Code to all ammonia valves, irrespective of their working temperature, to ascertain their tightness / leakage rate may be considered. This would reduce the risk of release of toxic ammonia vapours through a leaking valve. A proposal has been provided for this aspect in the annex to this document.

38 Drills and emergency exercises should cover the hazards and accidents with respect to the toxicity of ammonia.

39 Maintenance should also cover ammonia detection systems and ammonia treatment systems.

40 For bunkering operations, emergency procedure for ammonia treatment in case of leakage during bunkering should be added. It is recommended to require that no personnel shall be present in the bunkering manifold area during the transfer.

41 Suitable PPEs should be provided for ammonia fuel operations. PPE should be used by personnel before entering spaces which may contain ammonia, such as fuel tanks, fuel storage hold spaces, tank connection spaces, fuel preparation room, etc.

42 Special requirements for passenger ships may be developed. It would be more prudent to obtain experience with ammonia on cargo ships first and then proceed with passenger ships.

Action requested of the Sub-Committee

43 The Sub-Committee is invited to note the information in this document and to:

.1 refer to above paragraphs 6 to 42 when developing pertinent requirements; and

.2 note the gap analysis vis-à-vis ammonia as fuel and the IGF Code contained in the annex of this document.

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ANNEX

TABLE OF GAP ANALYSIS BETWEEN AMMONIA AS FUEL AND THE IGF CODE

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
Chpt.1 Preamble		The first paragraph states "The purpose of this Code is to provide an international standard for ships using low-flashpoint fuel, other than ships covered by the IGC Code", but ammonia is a gas fuel rather than a low-flashpoint fuel.		The first paragraph is suggested to be revised as "the purpose of this Code is to provide an international standard for ships using gas fuel and low-flashpoint fuel, other than ships covered by the IGC Code".
Chpt.2 General	2.1 Application	No gap found.	At present, the IGC code does not allow toxic goods to be used as fuel, which means ammonia could not be used as fuel on gas carriers.	Whether ammonia can be used as fuel on gas carriers belongs to the scope of IGC discussion, and it is recommended not to discuss it here.
	2.2 Definitions	2.2.3 The toxic consequences of ammonia vapor caused by leakage because of frequent disassembly of pipe connection of the portable fuel tank should be carefully considered. 2.2.5 The CNG definition does not apply.		2.2.3 It is recommended to limit the use of portable fuel tanks at the initial stage, unless a dedicated risk assessment (reliability, safety aspects, etc.) is conducted to ensure that achieved design is within allowed risk levels. 2.2.5 to be deleted.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		2.2.26 The LNG definition does not apply. 2.2.39 It is necessary to emphasize the consequences of toxic gas leakage. The others: There is no definition of ammonia emission control limit (or allowable exposure limit of ammonia) and ammonia treatment system on board. There is no definition of 'Master gas valve' or 'Master fuel valve'. There is no definition of 'Toxic area' or ' Toxic zone'.		2.2.26 Redefine ammonia fuel (refers to anhydrous liquid ammonia). Specifications of ammonia as marine fuel should also be developed. 2.2.39 It is suggested to revised as "……into the atmosphere so that an explosive atmosphere <u>or toxic vapour</u> could be formed." The others: It is suggested to add the allowable exposure limit of ammonia on board as well as the definition of ammonia vapour treatment system. (ammonia treatment system means a toxicity neutralization or mitigation unit, GCU is one of them). It is suggested to add the definition of 'Master fuel valve' and 'Toxic area' or 'Toxic zone'.
	2.3 Alternative design	No gap found		
	3.1 Goal	No gap found		

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
Chpt.3 Goal and functional requirements	3.2 Functional requirements	3.2.4 Toxic area is not considered The others: The requirement of personnel protective equipment is not considered.		3.2.4 It is suggested to revised as "Hazardous areas and toxic zone shall be restricted, ..." Ship shall also be provided with decontamination zones to provide first aid or emergency treatment to persons exposed to ammonia.3.2.4 is suggested to modify: Hazardous areas and toxic zones shall be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment. Ship shall also be provided with decontamination zones to provide first aid or emergency treatment to persons exposed to ammonia. It is suggested to add: Suitable personnel protective equipment is to be provided for protection of crew members engaged in fuel operations.
Chpt.4 General requirements	4.1 Goal	No gap found		
	4.2 Risk assessment	No gap found		

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	4.3 Limitation of explosion consequence	Limitation of toxicity consequence is not involved		Requirements to prevent toxic consequences should be development.
Chpt.5 Ship design and arrangement	5.1 Goal	No gap found		
	5.2 Functional requirements	5.2.1.2 Owing to the toxicity, whether the released ammonia can be directly discharged into the open air needs to be discussed.		5.2.1.2 It is suggested that ammonia should not be directly discharge into the atmosphere under normal operating conditions If the actual implementation is difficult, the operation emission concentration to open air should not exceed the defined emission limit. At the same time, the normal operation conditions should be clearly clarified.
	5.3 Regulations-General	No gap found.		It is suggested to add : Fuel tanks and their cofferdams are to be abaft of the collision bulkhead. 5.3.3 and 5.3.4 are suitable for ammonia fuel tank when considering the external damage caused by collision or grounding.
	5.4 Machinery space concepts	5.4.1.2 ESD engine room is not suitable for ammonia fuelled ships because of toxicity.		5.4.1.2 to be deleted

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	5.5 Regulations for gas safe machinery space	No gap found		
	5.6 Regulations for ESD-protected machinery spaces	ESD engine room is not suitable for ammonia fuelled ships because of toxicity.		5.6 to be deleted
	5.7 Regulations for location and protection of fuel piping	5.7.4 and 5.7.5 : ESD engine room is not suitable for ammonia fuelled ships because of toxicity.		5.7.4 and 5.7.5 to be deleted 5.2.1.4 and 5.7.3 put forward requirements to fuel pipes protected against mechanical damage.
	5.8 Regulations for fuel preparation room design	No gap found		It is suggested to add : Fuel preparation rooms shall be arranged to safely contain and manage leakage. The Reasonably Foreseeable Worst Case of leakage shall be determined.
	5.9 Regulations for bilge systems	Issues below may be considered : 1. Dedicated holding tanks for collecting drainage and leaked ammonia may be arranged. 2. The bilge from a space containing a potential ammonia release source may be kept in dedicated holding tanks before discharged after treatment.		It is suggested to add : 1. In the case that arrangements for overboard discharge are prohibited (except in emergency cases), dedicated holding tanks are to be arranged for ammonia solutions created for the safety measures of ammonia leakage such as water spray system or

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		3. The number and diameter of drainpipes or bilge suctions located in a space containing a sprinkler system shall be sufficient to prevent the presence of any ponding.		ammonia treatment system. 2. The bilge from a space containing a potential ammonia release source is to be kept in the dedicated holding tank on board, so that it will be discharged to a receiving device or into the sea after treatment. (Treatment here mainly refers to dilution with water or neutralization with acid.) 3. The number and diameter of drainpipes or bilge suctions located in a space containing a sprinkler system are to be sufficient to prevent the presence of any ponding. 4. The mixture of ammonia may be discharged outboard according to the standards and operational procedures required in MARPOL 73/78 ANNEX Ⅱ（The processed bilge shall meet the category requirements of ammonia aqueous (28% or less) in IBC, and then it can be discharged into the sea

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				according to the corresponding requirements of ammonia aqueous) and other appropriate regulations.
	5.10 Regulations for drip trays	Owing to the toxicity, drip tray for ammonia on open deck should be carefully considered.		It is suggested that ammonia pipes both on open deck and in enclosed spaces should be of double wall. The maximum possible leakage (including leaked fuel and spray water) shall be determined through risk analysis to design the capacity of the drip tray.
	5.11 Regulations for arrangement of entrances and other openings in enclosed space	5.11.4 ESD engine room is not suitable for ammonia fuelled ships. 5.11.3 It should be considered to not allow bolted hatch at TCS.		5.11.4 to be deleted 5.11.3 to be modified: Access to the tank connection space shall be independent and direct from open deck. Where a separate access from deck is not practicable, an airlock which complies with 5.12 shall be provided.
	5.12 Regulations for airlock	No gap found.		
	6.1 Goal			

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
Chpt.6 Fuel containment system	6.2 Functional requirements	It depends on the functional requirements for ammonia fuelled ships.		
	6.3 Regulations-General	1. Since ammonia may be storage under high pressure and ambient temperature condition, the general requirements for high pressure storage tank should be specified. 2. Even though ammonia is storage around its boiling point, the type C tank is generally adopted. From this point of view, the limitation of MARVS should be modified. (IGF Code 6.3. 1) 3. Considering the toxic property of ammonia; (1) Drip tray requirements for fuel storage tank on open deck should be deleted. (IGF Code 6.3. 10) (2) The tank connection on open deck also should be enclosed in gas tight space. (IGF Code 6.4.1.4) (3) Irrespective of the location of the fuel containment system, the fuel containment system should be gas tight towards adjacent spaces.		Refer to "Gaps between ammonia fuel and IGF Code". For 3(4) in left column, IGC Code 5.6.1.1 can be referred to.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		(4) a means should be provided to transfer ammonia to other tanks, shore facilities or other ships where means such as fuel pump is in failure. (To prevent the ammonia release into atmosphere)		
	6.4 Regulations for liquefied gas fuel containment	No gap found		
	6.5 Regulations for portable liquefied gas fuel tanks	Portable fuel tank should not be located on open deck, since it is difficult to enclose the tank connection by gas tight space. (IGF Code 6.5.2.2)		Refer to "Gaps between ammonia fuel and IGF code". Comments for "2.2 Definitions" about portable fuel tanks may be considered.
	6.6 Regulations for CNG fuel containment	The requirements for compressed gas fuel tank are not necessary for ammonia fuel storage.		Refer to "Gaps between ammonia fuel and IGF code".
	6.7 Regulations for pressure relief system	1. Considering the toxicity of ammonia; (1) the outlet position of ventilation should be further investigated. (IGF Code 6.7.2.7 &6.7.2.8) (2) Means for draining should not be led into air. (IGF Code 6.7.2.10)		Refer to "Gaps between ammonia fuel and IGF code".

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	6.8 Regulations on loading limit for liquefied gas fuel tanks	No gap found		
	6.9 Regulations for the maintaining of fuel storage condition	No gap found		
	6.10 Regulations on atmospheric control within the fuel containment system	1. Considering stress corrosion cracking, requirements for limiting oxygen concentration in fuel tanks or dissolved oxygen content into ammonia liquid should be added. 2. Since ammonia may react with carbon dioxide to form carbamic acid, inert gas using combustion gases should not be used for purging and gas-free applications.	IGC Code Chapter 17.12.8	Refer to "Gaps between ammonia fuel and IGF Code".
	6.11 Regulations on atmosphere control within fuel storage hold spaces (Fuel containment systems other than type C independent tanks)	Since ammonia does not form a flammable atmosphere at low concentrations, there is no need to inert the hold space at all times, but only to install inerting equipment to prevent the hold space from becoming flammable after a leak occurs.		6.11.2 of IGF Code can be only referred to.
	6.12 Regulations on environmental control of spaces surrounding type C	No gap found		

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	independent tanks			
	6.13 Regulations on inerting	Nothing, but refer to item 2 in 6.10 (Ban to use combustion gases for inerting)		
	6.14 Regulations on inert gas production and storage on board	No gap found		
Chpt.7 Material and general pipe design	7.1 Goal	It depends on the Goal for ammonia fuelled ships.		
	7.2 Functional requirements	1. To consider the corrosive property of ammonia 2. To consider the stress corrosion cracking property of ammonia		
	7.3 Regulations for general pipe design	1. Requirements for pipes of which design temperature is below -110 degree is not necessary for ammonia transfer piping. (IGF Code 7.3.4.5) 2. Priority for below hazards to be considered (IGF Code 7.3.1.4); (1) condensation moisture (2) detectability of leakage 3. To avoid venting from pressure relief valves on isolated pipe segments in liquid full condition, minimum design pressure of liquid fuel piping should be 18 bar or ammonia gas on isolated		1. 7.3.4.5 to be deleted.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		pipe segments should be led into ammonia release mitigation system. 4. Considering the toxicity and latent heat of ammonia, bellows should not be used for liquid pipes.		
	7.4 Regulations for materials	1. Reaction with cadmium to be considered. 2. Considering the corrosive property of ammonia, specific material to be banned. 3. Considering the stress corrosion cracking, requirements for limiting oxygen, fuel tank materials, etc. to be considered. 4. Test temperature of impact test in Table 7.3, 7.4 should be modified. 5. Requirements for CNG tank is not necessary (IGF Code 7.4.1.3)	2. IGC Code 17.12.1~17.12.8 to be added. 3. IGC Code 17.2.1 to be added	2. IGC Code 17.12.1~17.12.8 to be added. However, the text of IGC Code 17.2.6 should be modified as below; "Nickel steel containing more than nickel composition specified in recognized standard of "5% nickel" and carbon manganese steel not complying with the requirements of 17.12.2 and 17.12.3 are particularly susceptible to ammonia stress corrosion cracking and are not to be used for containment and

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				piping systems for the carriage of this product" 3. IGC Code 17.2.1 to be added 4. Test temperature of impact to be in line with minimum design temperature considering ammonia property.
Chpt.8 Bunkering	8.1 Goal	No gap found		
	8.2 Functional requirements	No gap found		
	8.3 Regulations for bunkering station	1. Considering the toxicity of ammonia, it is recommended to put forward requirements for enclosed and semi-enclosed filling station boundary surfaces, and to stipulate the entrance, air inlet and opening direction of living space, service space, machinery space and control station. 2. Considering the toxicity of ammonia, measures should be developed to prevent the vapour dispersion of the leaking ammonia fuel, and the requirements of safe treatment for the vapour	IGC Code 5.2.2.1.2 to be added.	Refer to "Gaps between ammonia fuel and IGF code".

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		generated in during bunkering should be put forward (IGF Code8.3.1.3/8.3.1.5). 3. Requirements for CNG bunkering station is not applied. So the 8.3.1.6 is to be deleted.		
	8.4 Regulations for manifold	No gap found		
	8.5 Regulations for bunkering system	No gap found		
Chpt.9 Fuel supply to consumers	9.1 Goal	No gap found	N/A	N/A
	9.2 Functional requirements	The functional requirements in this chapter of IGF code only consider flammability of fuel and fuel injection in gas form, does not consider toxicity of fuel and characteristics of ammonia fuel systems. Consideration should be given to following characteristics of ammonia fuel systems - ammonia fuel can be supplied in **liquid** state - ammonia gas is **toxic** and even very low concentration in air is harmful to crew, and detection and extraction of	IGC Code does not permit use of toxic cargo as fuel.	Functional requirements should be additionally developed to cover the following consideration. 1. any leakage into machinery space shall be prevented. 2. release to atmosphere through vent and bleed shall be subject to special consideration to prevent release gas from forming toxic zone near gas safe spaces 3. where fuel is supplied to consumer in the liquid form, venting and bleeding of fuel shall not be released to atmosphere in liquid form.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		leaked gas is not easy considering large volume and complicated form of engine room. And various density of ammonia gas depending on humidity is also unfavorable factor for detection and ventilation. Therefore, ammonia leakage in machinery spaces shall be prevented.		
	9.3 Regulations on redundancy of fuel supply	Applicable to ammonia system and no additional requirements for ammonia fuel seems to be needed	Use of cargo as fuel is regard as secondary fuel so that redundancy of fuel supply system is not required in Ch.16 of IGC Code.	none
	9.4 Regulations on safety functions of gas supply system	- For 9.4.4.1, fuel in bleed line shall not be directly released in the open air. Liquid and toxic ammonia fuel shall not be released to open deck without treatment of fuel to permissible level prior to release. - For 9.4.7, fuel supply branch shall not be directly vented to open air for same reason as mentioned for bleed line above.	IGC Code allows only gas safe concept for machinery space. However, there is a gap between IGC Code and IGF Code for detailed requirements for gas safe machinery space. IGC Code allows non continuous double barrier (i.e. air inlet) for low pressure fuel systems. For ammonia fuel, any possible leakage to machinery space to be prevented so that IGC concept for gas safe machinery space is not applicable to ammonia fuel.	Safety measure should be established to prevent liquid ammonia and excess ammonia vapour from releasing to open deck through vent and bleed line. Knock-out drum to prevent liquid release, gas absorber, gas combustion unit or returning to fuel tank are possible option for the safety measure. Furthermore, requirements for tank holding ammonia effluent generated form ammonia absorption

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		- For 9.4.10, ESD protected concept shall not be allowed to prevent any possible leakage to engine room with reason specified in the cell for 9.7 below.		system should be developed. The requirements for the tank should include, at least, capacity (based on permissible ammonia level for discharge to sea), vent, location, etc. And safe location of the end of vent/bleed line shall be defined for ammonia fuel taking into account toxic zone defined based on permissible concentration level of ammonia. Toxic zone around ammonia release source including vent/bleed outlet shall be defined for ammonia based on permissible level of concentration. TWA (25 ppm, mild irritation, 8h/day, repeated exposure) may considered as permissible level.
	9.6 Regulations for fuel supply to consumers in	No gaps found. Double barrier for fuel pipe and safety	IGC Code allows non continuous double barrier (i.e.	None

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	gas-safe machinery spaces	measure is considered to be applicable for ammonia fuel.	air inlet) in E/R for low pressure fuel systems. But the IGF Code does not allow any opening in E/R	
	9.7 Regulations for gas fuel supply to consumers in ESD-protected machinery spaces	ESD protected concept shall not be permitted to prevent any possible leakage to engine room for following reasons; - consequence of ammonia leakage(toxicity) in E/R differs from natural gas (flammability). - concentration level of toxic is much lower than flammability. - safety measure of ammonia leakage would differ from natural gas leakage.	IGC code does not permit ESD protected concept.	ESD protected concept shall not be permitted for ammonia fuel.
	9.8 Regulations for the design of ventilated duct, outer pipe against inner pipe gas leakage	9.8 of IGF Code seems applicable to ammonia fuel except K value defined for methane.	N/A	K value for ammonia should be given instead of K value for methane.
	9.9 Regulations for compressors and pumps	No gap found	N/A	None
Chpt.10 Power generation including propulsion and other gas consumers	10.1 Goal	No gap found	N/A	None
	10.2 Functional requirements	Functional requirements are related to flammability of fuel gas and does not consider toxicity.	N/A	Additional requirement should be developed to prevent unburned gas or venting gas from being exposed to person.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	10.3 Regulations for internal combustion engines of piston type	- Nature of ammonia very differ from other gas fuel. Requirements in 10.3 seems not to consider toxicity and low flammability of ammonia. Since ammonia engine has not been developed yet, it might be premature to cover all risk by prescriptive requirements. Therefore, I think risk assessment should be addressed for any risk which may arise in ammonia engine. - all gas vent fitted at engine (10.3.4), and explosion relief (10.3.1) fitted at exhaust system, and unburned gas (10.3.7) from exhaust system should be subject to additional consideration for toxicity of released gas.	N/A	- Risk assessment for ammonia engine should be addressed, specific hazards to be considered may be defined by further discussion. - Gas release sources should be prohibited or minimized with gas absorber.
	10.4 Regulations for main and auxiliary boilers	Ammonia toxicity is not considered in 10.4. Purging of fuel (10.4.8) should be discussed to prevent release gas from being exposed to person. However, if ammonia burning boiler on board is valid should be discussed considering flammability of ammonia gas.	N/A	Possibility of ammonia burning boiler should be discussed to decide developing ammonia boiler requirement or not.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	10.5 Regulations for gas turbines	Ammonia toxicity is not considered in 10.4. Access to turbine enclosure, outlet of pressure relief system fitted ag exhaust system should be discussed to prevent release gas from being exposed to person. However, if ammonia gas turbine on board is valid should be discussed considering flammability of ammonia gas.	N/A	Possibility of ammonia gas turbine should be discussed to decide developing ammonia gas turbine requirement or not.
Chpt.11 Fire safety	11.1 Goal	No gap found.	Ammonia cargo is defined only as toxic cargo and not defied as flammable cargo (requires only toxic vapour detection) in 'CHAPTER 19 SUMMARY OF MINIMUM REQUIREMENTS' of IGC Code	
	11.2 Functional requirements	No gap found.	N/A	N/A
	11.3 Regulations for fire protection	No gap found. But lower flammability of ammonia and severe gas leakage limitation for ammonia spaces should be considered.	N/A	Considering higher LEL (15%) and lower gas detection level (possibly 25 ppm) for ammonia spaces, probability to form flammable condition in the space is lower than natural gas. For this reason, I would like to discuss if

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				there is any possible mitigation of fire protection considering low flammability of ammonia. As ammonia is known not to start fire in the open air, it should be discussed whether fire protection toward fuel tank and bunkering station is necessary or not.
	11.4 Regulations for fire main	No gap found. But lower flammability of ammonia should be considered.	N/A	As ammonia is known not to start fire in the open air, it should be discussed whether 11.4.2 is necessary or not.
	11.5 Regulations for water spray system	- Water spray systems for cooling and fire prevention would may also be used combinedly for ammonia gas absorption system.	- Water spray systems for cargo tank and process system of flammable or toxic product (11.3)	- Water spray system for ammonia gas absorption system could be specified in a different chapter (new chapter for 'toxicity safety' may be an option for all toxic related requirements (toxic zone, gas absorption system, ammonia bilge holding and discharge, personnel protection equipment) and possible modification of requirements (e.g. pump capacity considering water spray system for ammonia

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				gas absorption) should be reviewed.
	11.6 Regulations for dry chemical powder fire-extinguishing system	No gap found.	N/A	N/A
	11.7 Regulations for fire detection and alarm system	No gap found.	N/A	N/A
Chpt.12 Explosion prevention	12.1 Goal	Prevention of toxic injury to be included	No direct details in IGC Code regarding ammonia toxicity areas as only LNG is allowed as fuel. Only Section 8 of IGC Code provides some information related to minimum distances from vents.	Add the statement, for example, to the Goal "…., and to provide for the prevention of toxic injury."
	12.2 Functional requirements	Measures to reduce the probability of toxic injury not stated.	As above	Add details that, for example: - the number of leakage sources (e.g. flanged joints) is to be reduced, and - appropriate safeguards to prevent injury in the event of a toxic release is to be implemented.
	12.3 Regulations–General	Toxic area classification study not mentioned. And allowance for ESD-protected machinery spaces not considered for ammonia.	As above	Specify that the scope of the toxic areas' classification study is to consider all machinery and equipment which could represent a source of release of toxic gas in:

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				1. normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the fuel-gas system; and, 2. equipment intended for recovery from unintended releases of gas (e.g. venting systems). Also address that Life-saving equipment, muster stations and escape routes from other locations are not to be in defined toxic areas. Consider not to allow ESD-protected machinery spaces. Consider the necessity of hazardous area determination for open areas based on low flammability of ammonia.
	12.4 Regulations on area classification	Zoning principle (like hazardous areas) for toxic areas not specified.	As above	Proposal to define toxic areas as below: Toxic areas shall be classified into zones based upon the frequency of the occurrence and duration of a toxic atmosphere, as follows:

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				• Zone A: an area in which a toxic atmosphere is present continuously or for long periods or frequently; and, • Zone B: an area in which a toxic atmosphere is not likely to occur during normal operation but, if it does occur, will persist for a short period only. A toxic atmosphere is one in which the ammonia concentration presents a significant health hazard (to be discussed if reference to ppm of ammonia is required). C^2*t=Constant (C- concentration in ppm, t - time in hours)
	12.5 Hazardous area zones	Toxic areas not defined for ammonia.	It is reasonable to consider minimum distances from vent masts, ventilation outlets as per IGC Code, Sections 8.2.10, 8.2.11, 8.2.12 as ammonia is allowed cargo in IGC Code.	Provide the examples of toxic areas, like: Zone A toxic areas include the interiors of fuel tanks, equipment and pipework containing fuel, and any pipework for pressure-relief or other venting systems for fuel

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				tanks, pipes and equipment containing fuel. Zone B toxic areas include areas or spaces in which potential leak sources are located, including the interiors of ducts and double pipes and areas in the vicinity of openings and outlets from such areas and spaces. Specify the minimum distances from vent masts, ventilation outlets from toxic areas, reference to IGC Code (Section 8). Also, possible to consider as alternative distances from IBC Code, Section 15.12 (Toxic products). Additionally, specify the minimum distances from ammonia bunkering manifolds.
Chpt.13 Ventilation	13.1 Goal	No gaps found	IGC Code, Chapter 12 Goal is *to ensure that arrangements are provided for enclosed spaces in the cargo area to control the accumulation of flammable and/or toxic vapours*.	Flash evaporation of compressed liquefied Ammonia is to be considered as its release would lead to the creation of Ammonia pools. This behaviour aspect of

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				Ammonia is different from natural gas, therefore is to be specifically considered.
	13.2 Functional requirements	No gaps found	No gaps found	N/A
	13.3 Regulations–General	No clear information with reference to redundancy level of the ventilation in the spaces containing ammonia. No clear actions in case of ventilation loss in the spaces with ammonia. No details with reference to closing devices for all air intakes and other openings to accommodation, service spaces, control stations, machinery spaces, and other manned spaces upon detection of ammonia.	No gaps found	Suggested to: - Have 100% capacity redundancy of the fans. - Specify, that *Loss of ventilation in the bunkering station or in ducts and double-walled pipes transferring bunker fuel to the fuel storage tank shall activate an emergency stop of the bunkering process via the ESD system,* *Loss of ventilation in the tank connection space, in the fuel preparation room, or in fuel supply ducts or double-walled pipes before master gas valve(s) shall activate an automatic shutdown of the tank master isolation valve.* *Loss of ventilation in*

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				fuel supply ducts or double-walled pipes after the master gas valve(s) shall activate an automatic shutdown of the master gas valve(s) required to isolate the unventilated fuel supply ducts or double pipes. - Clarify on the closing devices for mentioned areas (manual closing and automatic). - Consideration is to be given for hazardous areas of Ammonia on open decks (IGF Code 13.3.5). - IGF, Section13.3.6 should have reference to toxic zones as well. It should be evaluated if acceptable to locate ventilation inlet for Double walled annular spaces within other toxic zones as recirculation of some toxic air into Double walled annular spaces

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				is not critical. - IGF Code 13.3.7: Should be considered to allow grouping of ventilation outlets from compartments where ammonia may leak to limit the extent of toxic zones on board (ensuring no backpressure for such arrangements). - Introducing increased ventilation rates (catastrophe ventilation) in the event of gas detection should be considered. - Introducing water mist system or other water based safety system in ventilation system to bind to toxic ammonia gas in the event of a leak should be considered.
	13.4 Regulations for tank connection space	No gaps found	No gaps found	- Introducing increased ventilation rates (catastrophe ventilation) in the event of gas detection should be considered.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
	13.5 Regulations for machinery spaces	It is observed that ESD-protected machinery space is allowed	No gaps found	ESD-protected machinery space shall not be applied for ammonia.
	13.6 Regulations for fuel preparation room	No details with reference to emergency ventilation in case of worst-case leakage scenario.	No gaps found	Consideration is to be given for the activation of emergency ventilation in case of worst-case leakage scenario when there is significant health hazard from ammonia.
	13.7 Regulations for bunkering station	No details with reference to emergency ventilation in case of worst-case leakage scenario.	No gaps found	Consideration is to be given for the activation of emergency ventilation in case of worst-case leakage scenario when there is significant health hazard from ammonia.
	13.8 Regulations for ducts and double pipes	No gaps found	No gaps found	- Introducing increased ventilation rates (catastrophe ventilation) in the event of gas detection should be considered. Introducing water mist system or other water based safety system in ventilation system to bind to toxic ammonia gas in the event of a leak should be considered.
	14.1 Goal	No gaps found	No gaps found	N/A

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
Chpt.14 Electrical installations	14.2 Functional requirements	No gaps found	No gaps found	N/A
	14.3 Regulations–General	Temperature Class and Gas Group is not specified for Ammonia.	No gaps found	Electrical equipment located in hazardous areas shall be suitable for ammonia atmospheres and at least meet the Temperature Class T1 and Gas Group IIA.
Chpt.15 Control, monitoring and safety systems	15.1 Goal	No gaps found	IGC Code, Section 13 Goal is *To ensure that the instrumentation and automation systems provides for the safe carriage, handling and conditioning of cargo liquid and vapour.*	Consideration might be given to Functional Safety aspects to achieve sufficient risk reduction, such as IEC61508, or at least acknowledge it could be applicable with such as "shall identify the technique(s) to appropriately manage functional safety requirements and these are to be appropriately justified"
	15.2 Functional requirements	There is no clear statement on fail-safe principle of gas/fuel safety system. Also, there is no clear reference to IACS UR E 22 (programmable electronic systems).	Fail safe principle is stated in Section 13.9.1.	It is recommended to state that gas safety system is to be fail safe. It is recommended to specify that gas safety system is as required by IACS UR E22.
	15.3 Regulations–General	In case of integrated gas control, monitoring and safety	Risk based approach is required in Section 13.9.3	It is recommended to specify that gas control /

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		system no details about risk-based approach (FMEA, etc.)		monitoring and safety system is to be designed based on risk-based techniques.
	15.4 Regulations for bunkering and liquefied gas fuel tank monitoring	No gaps found Maybe reference for the proper materials of instrumentation in contact with ammonia	No gaps found	Maybe reference for the proper materials of instrumentation in contact with ammonia
	15.5 Regulations for bunkering control	No gaps found	No gaps found	N/A
	15.6 Regulations for gas compressor monitoring	No gaps found	No gaps found	N/A
	15.7 Regulations for gas engine monitoring	No gaps found	No gaps found	N/A
	15.8 Regulations for gas detection	No details of gas detection limits for ammonia. No requirements for the voting principle for gas detectors. No requirements for gas detectors in bunkering station, air intakes for accommodation spaces, etc. No details where gas detectors ae to be positioned. No details that gas detectors are to be readily available for the calibration / testing at the point of installation.	Section 13.6.5 allows toxic gases to be detected by portable gas detectors only.	It is recommended to apply the following: *Gas detection system is to comply with IEC 45544 series of standards.* *All gas detection limits are to be in accordance with the requirements of, and to the satisfaction of, the Administration.* *At least three gas detectors shall be provided at each location and the total number of detectors in*

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		No reference to IEC 45544 series of standards *(Workplace atmospheres — Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours)*		*each location shall consider the size, layout, and ventilation of the space.* *Permanently installed gas detectors shall also be fitted in:* *1. the bunkering station.* *2. at ventilation inlets to accommodation, service spaces, control stations, machinery spaces, and other manned spaces; and,* *3.locations and spaces if required based on the risk assessment.* *The detectors shall be located where vapour may accumulate and considering credible points of leakage, specific gravity of the vapour, process pressure, ambient conditions, equipment arrangement, accumulation points and ventilation air flows. The location of detectors shall be determined in accordance*

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				with a dispersion modelling study. *Alarm and safety systems shall be activated by a voting system with the following logic circuit:* *1. alarm systems shall be activated with a one-out-of-three logic circuit (1oo3); and,* *2. safety systems shall be activated with a two-out-of-three logic circuit (2oo3).* *Arrangements are to allow gas detectors to be readily tested and calibrated in their mounted positions.* And additionally: - Gas detection at vent mast to be considered to monitor for too high normal operation emissions of ammonia and to give warnings/alarms in case of high emissions.

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				Visible and audible alarm should be indicated on deck in vicinity of toxic ventilation outlets if gas detection in any location where ammonia may leak or in vent mast to give warnings to nearby people.
	15.9 Regulations for fire detection	No gaps found	No gaps found	N/A
	15.10Regulations for ventilation	ESD-protected machinery space is mentioned in IGF Code now, but for ammonia as fuel there is no statement.	No gaps found	Suggested to clarify on the allowance of ESD-protected machinery spaces.
	15.11Regulations on safety functions of fuel supply systems	There are no details with reference to other essential equipment installed where failure could lead to ammonia release (e.g. water seals, scrubbers, etc.)	No gaps found	It is advised to specify that: *Control, alarm, and safety systems associated with other essential equipment installed to ensure fuel released to atmosphere does not present a significant health hazard (e.g. water seals, scrubbers, etc.), shall be in accordance with the manufacturer recommendations and as identified in the risk assessment.* And additionally: *- Gas safety functions for ESD valve at fuel*

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				preparation room bulkhead to be considered. *- Purging of leaking pipe segments to be considered upon leak detection, for piping outside FPR/TCS, to limit the amount of leaked ammonia. Purging to happen without unacceptable emissions of ammonia vapour to air.* *- Proper ESD to be implemented in the event of occurring condensation of Ammonia fuel.*
Chpt.16 Manufacture, workmanship and testing	16.1 General	No gap found.		
	16.2 General test regulations and specifications	No gap found.		
	16.3 Welding of metallic materials and non-destructive testing for the fuel containment system	No gap found.		
	16.4 Other regulations for construction in metallic materials	No gap found.		
	16.5 Testing	No gap found.		
	16.6 Welding, post-weld heat treatment and non-destructive testing	No gap found.	IGC 17.12.3 to 5 may be considered.	It is suggested to add the following text: *If carbon-manganese steels*

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
				with yield strength exceeding 440 N/mm2 are used, the completed cargo tanks, piping, etc., shall be given a post-weld stress relief heat treatment. *Process pressure vessels and piping of the condensate part of the refrigeration system shall be given a post-weld stress relief heat treatment when made of carbon-manganese steel or nickel steel1.* *The tensile and yield properties of the welding consumables shall exceed those of the tank or piping material by the smallest practical amount.*
	16.7 Testing regulations	16.7.1 Consider extending the scope of IGF 16.7.1 (Type testing of valves) to all valves, irrespective of their working temperature, to ascertain their tightness / leakage rate. This would allow the risk of release of toxic ammonia vapours through a leaking valve to be reduced. 16.7.2: No gap found.		Suggest the following modification of IGF 16.7.1: *Type testing of piping components* *Valves* *Each type of piping component shall be subject to the following type tests:* *[…]*

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		16.7.3: No gap found.		
Chpt.17 Drills and emergency exercises		No gap found.		It is suggested to modify the last paragraph as follows: *The response and safety system for hazards and accident control, in particular with respect to the toxicity of ammonia, shall be reviewed and tested.*
Chpt.18 Operation	18.1 Goal	No gap found.		
	18.2 Functional requirements	No gap found.		Suggest the following modification in IGF 18.2.4: *.4 the ship shall be provided with suitable emergency procedures, covering in particular the risk posed by the toxicity of ammonia.*
	18.3 Regulations for maintenance	Maintenance should also cover the ammonia detection systems and ammonia vapour treatment systems (such as the "recovery" and "absorption" systems referred to above).		Suggest adding the following test: *18.3.4 The maintenance, inspection and testing of the ammonia vapours detection and treatment systems are to be carried out in accordance with an approved procedure.*
	18.4 Regulations for bunkering operations	18.4.1: No gap found.		

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		18.4.2: Add an item on emergency procedure for ammonia treatment in case of leakage during bunkering operations. 18.4.3: No gap found. 18.4.4: No gap found. 18.4.5: No gap found. 18.4.6.1: No gap found. 18.4.6.2: Owing to the high toxicity of ammonia vapours, no personnel should be present in the bunkering manifold area during the transfer. 18.4.6.3: To be deleted if the use of portable tanks is not considered (see above comments on Part A, § 2.2.3).		
	18.5 Regulations for enclosed space entry	18.5.1: The toxicity of ammonia vapours should be considered instead of their flammability, since the permissible exposure limit of ammonia is far below its LFL. 18.5.2: Consider deletion of this regulation for the reason given above (§ 18.5.1). Consider adding a regulation requiring suitable PPE to be		Suggest modifying 18.5.1 as follows: *18.5.1 Under normal operational circumstances, personnel shall not enter fuel tanks, fuel storage hold spaces, void spaces, tank connection spaces or other enclosed spaces where* ammonia vapours may accumulate, unless the ammonia concentration *of the atmosphere in* such

Content of the IGF Code		Gaps between ammonia fuel and the IGF Code	IGC Code provisions to be considered	Proposals to fill the gaps
		used by personnel entering the spaces listed in 18.5.1.		space is determined by means of fixed or portable equipment to ensure absence of toxic ammonia concentration, i.e. concentration below [the permissible exposure limit] [25 ppm].
	18.6 Regulations for inerting and purging of fuel systems	No gap found.		
	18.7 Regulations for hot work on or near fuel systems	No gap found.		
Chpt.19 Training	19.1 Goal	No gap found.		
	19.2 Functional requirements	No gap found.		The expression "gases or other low flashpoint fuels" is to be substituted with "ammonia as fuel".