Requirements for

Ammonia Fueled Vessels

September 2023

REQUIREMENTS FOR

AMMONIA FUELED VESSELS
SEPTEMBER 2023

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

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Foreword *(1 September 2023)*

Due to the commitment from the International Maritime Organization (IMO) to reduce Green House Gas (GHG) emissions from shipping, the use of Liquified Natural Gas (LNG), methanol, ethane, Liquified Petroleum Gas (LPG), hydrogen, ammonia and other gases or low-flashpoint fuels are expected to become more widely adopted by the marine industry as a substitute for conventional residual or distillate marine fuels. In response to the IMO GHG reduction targets, the marine industry has increased its interest in the use of ammonia as a marine fuel due to its zero-carbon fuel properties and the ability to produce ammonia from renewable and sustainable sources. This document addresses the use of ammonia as a marine fuel.

The ABS criteria to be applied to gas or other low flashpoint fueled ships are detailed in Part 5C, Chapter 13 of the ABS *Rules for Building and Classing Marine Vessels* (*Marine Vessel Rules*), which incorporates the IMO *International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels* (IGF Code).

This document applies to vessels covered by the IGF Code as addressed by Chapter 5C-13 of the *Marine Vessel Rules*. ABS will consider application of this document to liquefied gas cargo vessel covered by *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code), as addressed by 5C-8 of the *Marine Vessel Rules*, on a case-by-case basis.

The applicable edition of the *Marine Vessel Rules* is to be used in conjunction with this document.

The July 2022 version changes the document type from “Guide” to “Requirements”. “Requirements” documents contain mandatory criteria for Classification and issuance of Class Certificates, while Guides contain only requirements for optional Notations (see 1-1-4/1.5 of the ABS *Rules for Conditions of Classification (Part 1)*). The title is changed from "*Guide for Ammonia Fueled Vessels*" to "*Requirements for Ammonia Fueled Vessels*". Accordingly, editorial changes are made throughout this document.

The September 2023 version updates the requirements covering the technological advancements, assessments and studies that have been developed by the industry.

This document becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version is the most current.

Also refer to the ABS Sustainability Whitepaper: *Ammonia as Marine Fuel*, for supplemental information on ammonia as a marine fuel.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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AMMONIA FUELED VESSELS

CONTENTS

SECTION 1
Introduction

1 Scope *(1 September 2023)*

The international regulations pertaining to gas or other low flashpoint fueled ships, other than those covered by the IGC Code, are those included in the IMO *International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels* (IGF Code), which entered into force on 1 January 2017. The IGF Code has been incorporated along with ABS requirements in Part 5C, Chapter 13 of the ABS *Rules for Building and Classing Marine Vessels* (*Marine Vessel Rules*).

The IGF Code currently only includes detailed prescriptive requirements for natural gas (methane) applications. All other low flashpoint fuels or gases must demonstrate an equivalent level of safety by application of the Alternative Design methodology as specified in International Convention for the Safety of Life at Sea (SOLAS) Chapter II-1 Regulation 55 and guidelines referenced by footnote MSC.1/Circ.1212 or associated guidelines MSC.1/Circ.1455.

Where other prescriptive IMO requirements exist for specific gases or other low flashpoint fuels, either by regulation, or as interim guidelines, these may be applied in lieu of the Alternative Design criteria, subject to agreement by the flag Administration. Currently no such IMO instruments exist for the use of anhydrous ammonia as fuel.

This document provides guidance for the design, construction, and survey of vessels utilizing anhydrous ammonia (ammonia) as fuel. This document focuses on systems and arrangements provided for the use of ammonia for propulsion and auxiliary systems.

Where anhydrous ammonia is intended for use as fuel on vessels carrying passengers on board, e.g., passenger vessels, ferries etc., additional design and operational mitigations are to be provided for the protection of passengers from ammonia exposure. The adequacy of the mitigations is to be evaluated during vessel specific risk analysis.

2 Objective

This document provides Classification requirements for the arrangements, construction, installation and survey of machinery, equipment and systems for vessels operating with ammonia as fuel to minimize risks to the vessel, crew and environment.

3 Classification Notations

3.1 Alternative Low Flashpoint Fueled Ship - Ammonia

The **LFFS** notation is required and will be assigned where a vessel is arranged to burn ammonia for propulsion and/or auxiliary purposes and is designed, constructed and tested in accordance with the

requirements of this document. The **LFFS** notation will be assigned in association with the specific fuel and one or more of the following additional equipment notations (e.g. **LFFS(DFD - Ammonia)**).

Vessels seeking the **LFFS** notation for ammonia as fuel are also to meet the criteria and be assigned the **ACC**, **ACCU** or **ABCU** notations for remote monitoring (See also 5/4.3).

Commentary:

Conventional fuel flashpoint testing refers to closed cup testing of fuel oils and is thus not an applicable test for gases. For the purpose of this document, the **LFFS** notation applies to IGF Code vessels for which the IMO Alternative Design process is applicable.

For more information on ABS notations for IGF Code vessels, see also 5C-13-1/1.2 of the *Marine Vessel Rules*.

End of Commentary

3.2 Dual Fuel Diesel Engine Power Plant *(1 September 2023)*

Where a dual fuel diesel engine power plant is installed, the unit is to be designed, constructed and tested in accordance with this document and Section 5C-13-10 of the *Marine Vessel Rules*, and the mandatory **DFD** notation will be assigned.

3.3 Reliquefaction System *(1 September 2023)*

Where a Reliquefaction System is designed, constructed and tested in accordance with 5C-13-6/9.3 and Appendix 5C-13-6A2 of the *Marine Vessel Rules*, the optional **RELIQ** notation will be assigned upon the Client's request.

Where the system is used to maintain fuel tanks' pressure and temperature, the **RELIQ** notation is required.

3.4 Fuel Ready Notation *(1 September 2023)*

Where a ready notation is requested for ammonia fuel, the optional notation **Ammonia Fuel Ready Level 1**, **2** or **3** may be applied according to the ABS *Guide for Gas and Other Low-Flashpoint Fuel Ready Vessels*.

4 Certification

ABS design review, survey, testing, and the issuance of reports or certificates constitute the certification of machinery, equipment and systems. See also 4-1-1/3 of the *Marine Vessel Rules*.

5 Flag Administration Approval *(1 September 2023)*

Where the conditions of the document are proposed to be used to comply with or support the IGF Code Alternative Design process, such application is subject to approval by the Flag Administration prior to issuance of relevant statutory certificates on behalf of the same Flag Administration by ABS. Refer to 5C-13-2/3 of the *Marine Vessel Rules* for the requirements on the Alternative Design process.

6 Format *(1 September 2023)*

This document is based on the technical requirements of the *International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels* (IGF Code) which is contained in its entirety in Chapter 5C-13 of the *Marine Vessel Rules* and is required for classification.

The term "shall be" is to be understood to read as "is to be" or "are to be" and unless otherwise specified. The term "Administration" as used in this document is to be read as "Flag Administration" (See Subsection 1/5).

This document specifies only the unique requirements applicable to vessels using ammonia as fuel. This document is always to be used in association with the IGF Code, as incorporated in Chapter 5C-13 of the *Marine Vessel Rules*, and with other relevant Sections of the Rules.

Where this document includes cross references to Parts A-1, B-1 and C-1 of the IGF Code (Sections 5C-13-5 to 5C-13-18 inclusive of the *Marine Vessel Rules)*, the terms “natural gas”, “LNG” or “gas”, as related to fuel, are to be understood to be referring to anhydrous ammonia for application of the requirements of this document.

The text contained in this document that comes directly from the IGF Code is presented in italics.

SECTION 2
General

1 Application

This document is to be applied to both new construction and existing vessel conversions, regardless of size, including those of less than 500 tons gross tonnage, utilizing ammonia as fuel.

Commentary:

This document applies to ships covered by the IGF Code. ABS will consider application of this document to ships falling under the scope of the IGC Code on a case-by-case basis, provided such proposals are arranged in accordance with the requirements of the IGC Code and demonstrate the same level of safety as natural gas and with agreement of the flag Administration.

End of Commentary

2 Definitions *(1 September 2023)*

For the purpose of this document, the terms used have the meanings defined in the following paragraphs. Terms not defined have the same meaning as in 5C-13-2/2 of the *Marine Vessel Rules*.

i) *"Breadth"* (B) is the greatest molded breadth of the ship at or below the deepest draught (summer load line draught) (refer to SOLAS regulation II-1/2.8).

ii) "*Engine room*" is a machinery space containing ammonia fueled engine(s).

iii) "*Fuel*" means anhydrous ammonia (NH_3) in its liquified or gaseous state. The terms "fuel" "ammonia" and "NH_3" used in this document refer to anhydrous ammonia.

iv) "*Fuel treatment or vent control system*" is a system to reduce the concentration of ammonia released to atmosphere.

v) "*Fuel preparation room*" is a space containing pumps, compressors, heat exchangers, reliquefaction equipment and/or vaporizers for the preparation of the ammonia fuel.

vi) "*FVT*" means Fuel Valve Train and refers to the series of fuel regulator valves, control valves, including the double block and bleed valve arrangement. The FVT is commonly referenced with varying terminology, including Fuel Valve Unit (FVU) or Gas Valve Unit (GVU) or Gas Regulating Unit (GRU).

vii) "*Gas dispersion analysis*" is the analysis of the dispersion behavior of gases using appropriate modeling techniques such as computational fluid dynamics (CFD) analysis.

viii) "*Gas freeing*" is the process carried out to achieve a safe tank atmosphere. It includes purging the hazardous tank atmosphere with an inert gas or other suitable medium to dilute the hazardous vapor to a level where air can be safely introduced; and replacing the diluted inert atmosphere with air.

ix) "*Master Fuel Valve*" is an automatic shut-off valve in the fuel supply line to each consumer and is located outside the machinery space of the consumer. This has the same functionality as "Master Valve", "Master Gas Valve" or "Master Gas Fuel Valve" defined under 5C-13-2/2.45 of the *Marine Vessel Rules*.

x) "*Portable tank*" is an independent tank that is:

a) easily connected and disconnected to/from ship systems; and

b) easily removed from ship and fitted on board ship.

xi) "*Single failure*" is where loss of intended function occurs through one fault.

xii) "*Tank Connection Space*" is a space surrounding all tank connections and tank valves.

xiii) *"Toxic Areas"* are areas where the risk of ammonia toxicity from potential leak sources exist.

3 Alternative Design

Equipment, components, and systems for which there are specific requirements in this document, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this document. This, however, is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall safety and strength requirements of this document or associated references. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this document is met. In all cases, the equipment, component or system is subject to design review, survey during construction, tests and trials, as applicable, by ABS to verify its compliance with the alternative arrangements or standards. The verification process is to be equivalent to that outlined in this document. See also 4-1-1/1.7 of the *Marine Vessel Rules*.

4 Plans and Data to be Submitted

Plans, data, and specifications are to be submitted as follows.

4.1 Ship Arrangements and Systems *(1 September 2023)*

For Section 5, plans and specifications covering the ship arrangements and systems listed below are to be submitted, and are to include, as applicable:

i) Risk assessment plan and associated risk assessment report(s) (See Subsection 4/2)

ii) General arrangement of vessel

iii) Fuel storage arrangements

iv) Fuel supply system arrangements

v) Fuel bunkering station arrangements

vi) Hazardous area classification plan

vii) Toxic area plan

viii) Inert gas system details

ix) Fuel treatment or vent control system specification, details and arrangement

x) Vent mast and venting arrangements

xi) Operations and maintenance manuals (to be submitted for reference purposes only)

xii) Emergency response plan (to be submitted for reference purposes only)

xiii) Description of the control, monitoring and safety systems, including alarm and shutdown monitoring and cause and effect diagram (See Section 15)

4.2 Fuel Containment System

For Section 6, plans and specifications covering the fuel containment system listed below are to be submitted, and are to include, as applicable:

i) General arrangement plans of the vessel showing the position of the fuel containment system and details of manholes and other openings in fuel tanks

ii) Plans of the hull structure in way of the fuel tanks, including the installation of attachments, accessories, internal reinforcements, saddles for support and tie-down devices.

iii) Plans of the structure of the fuel containment system, including the installation of attachments, supports and attachment of accessories.

For independent pressure fuel tanks, the standard or Code adopted for the construction and design is to be identified. Detailed construction drawings together with design calculations for the pressure boundary, tank support arrangement and analysis for the load distribution are to be provided. Anti-collision, chocking arrangement and design calculations are to be provided.

iv) Distribution of the specification, grades and types of steel proposed for the structures of the hull and of the fuel containment system, including attachments, valves, accessories, etc., together with the calculation of the temperatures on all of the structures which can be affected by the low temperatures of the fuel.

v) Design loads and structural analyses for the fuel storage tank(s) together with complete stress analysis, as applicable, of the hull and fuel containment system including sloshing analysis

vi) Specifications and plans of the insulation system and calculation of the heat balance

vii) Procedures and calculations of the cooling down and loading operations, including loading limit curve

viii) Loading and unloading systems, venting systems, and gas-freeing systems, as well as a schematic diagram of the remote-controlled valve system

ix) Details and installation of the safety valves and relevant calculations of their relieving capacity (supported by relieving scenarios), including back pressure

x) Details and installation of the various monitoring and control systems, including the devices for measuring the level of the fuel in the tanks and the temperatures in the containment system

xi) Schematic diagram of the ventilation system indicating the vent pipe sizes and location of the openings

xii) Fuel tank pressure accumulation calculation

xiii) Schematic diagram of the refrigeration system together with the calculations concerning the refrigerating capacity

xiv) Details of the electrical equipment fitted in the fuel containment area and of the electrical bonding of the fuel tanks and piping

xv) Details of testing procedures of fuel tanks and liquid and vapor systems

xvi) Diagram of inert-gas system or hold-space environmental-control system

xvii) Diagram of gas and leak detection systems

xviii) Schematic-wiring diagrams

xix) Details of all fuel and vapor handling equipment

xx) Details of fire extinguishing systems

xxi) Welding procedures, stress relieving and non-destructive testing plans

xxii) Construction details of submerged fuel pumps including material specifications

xxiii) Operating and maintenance instruction manuals (submitted for reference purposes only)

xxiv) Testing procedures during sea/gas trials (submitted for survey verification only)

xxv) Inspection/survey plan for the liquefied fuel containment system

4.3 Fuel Bunkering System

For Section 8, plans and specifications covering the fuel bunkering system listed below are to be submitted, and are to include, as applicable:

i) General arrangement of the gas fuel bunkering system including location of the gas detectors, electrical equipment and lighting

ii) Detailed drawings of the bunkering station, manifolds, valves, couplings and control stations

iii) Gas fuel piping systems including details of piping and associated components, design pressures, temperatures and insulation where applicable

iv) Material specifications for manifolds, valves and associated components

v) Weld procedures, stress relieving and non-destructive testing plans

vi) Ventilation system

vii) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems

viii) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions

ix) Details of all electrical equipment in the bunkering and control stations

x) Equipotential bonding and insulating flange arrangement

xi) Emergency shutdown (ESD) arrangements and ESD flow chart

xii) Operating and maintenance instruction manuals (submitted for reference purposes only)

xiii) Testing procedures during sea/gas trials (submitted for survey verification only)

4.4 Fuel Supply System

For Section 9, plans and specifications covering the fuel supply system listed below are to be submitted, and are, as applicable, to include:

i) General arrangement of the fuel preparation room including location of the gas and leak detectors, electrical equipment and lighting

ii) Doors and other openings in fuel preparation rooms

iii) Ventilation systems

iv) Material specifications for compressors, pumps, evaporators, vaporizers, condensers, coolers, heaters, valves and associated fuel supply/return/treatment components

v) Fixed gas and leak detection and alarm systems, and associated shut-off and shutdown systems

vi) Fuel piping systems including details of piping and associated components, design pressures, temperatures, insulation and fuel processing or treatment systems, where applicable

vii) Weld procedures, stress relieving and non-destructive testing plans

viii) Compressors

ix) Vaporizers/heaters

x) Pressure vessels

xi) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions

xii) Details of all electrical equipment in the fuel preparation room

xiii) Electric bonding (earthing) arrangement

xiv) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the fuel supply system

xv) Emergency shutdown arrangements

xvi) Operating and maintenance instruction manuals (submitted for reference purposes only)

xvii) Testing procedures during sea/gas trials (submitted for survey verification only)

4.5 Power Generation Prime Movers and Accessories

For Section 10, plans and specifications covering the power generation prime movers and accessories listed below are to be submitted, and are, as applicable, to include:

i) General arrangement of the engine room (non-hazardous, "gas-safe", machinery spaces) including location of the gas and leak detectors, electrical equipment and lighting

ii) Ventilation systems

iii) Fixed gas and leak detection and alarm systems, and associated shut-off and shutdown systems

iv) Fuel specification(s)

v) Fuel piping systems including schematics for main and pilot fuel systems together with details of piping and associated components, design pressures and temperatures

vi) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions

vii) Details of the electrical equipment

viii) Electric bonding (earthing) arrangement

ix) Arrangements and details of crankcase protection

x) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the engine

xi) Safety concept and/or risk analysis documentation

xii) Arrangement of explosion protection for air inlet manifolds and for exhaust manifolds including design basis and size calculations

xiii) Emergency shutdown arrangements

xiv) List of certified safe equipment

xv) Operating and maintenance instruction manuals (submitted for reference purposes only)

xvi) Testing procedures during sea/gas trials (submitted for survey verification only)

xvii) Engine specific time referenced by 5C-13-10/3.1.7 of the *Marine Vessel Rules*, after which if the engine has not started then the fuel gas supply is to be shut off and exhaust system is to be purged.

SECTION 3

Goal and Functional Requirements

1 Goal

The goal of this document is to enhance the safety and environmental-friendliness of the design, construction and operation of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using ammonia as fuel.

2 Functional Requirements

The functional requirements of 5C-13-3/2 of the *Marine Vessel Rules* are applicable and are included below with additional functional requirements that are to be considered, but not limited to:

2.1

The safety, reliability and dependability of the systems shall be equivalent to that achieved with new and comparable conventional oil-fueled main and auxiliary machinery.

2.2

The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions shall be initiated.

2.3

The design philosophy shall ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power.

2.4

Hazardous and toxic *areas 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.*

2.5

Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.

2.6

Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.

2.7

System components shall be protected against external damages.

2.8

Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.

2.9

It shall be arranged for safe and suitable fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system shall be designed to prevent venting under all normal operating conditions including idle periods.

2.9 (ABS) *(1 September 2023)*

For the purposes of venting ammonia, "safety reasons" means unavoidable releases necessary to protect personnel or equipment. For example, pressure relief valve operation for protection of fuel tanks or emergency actions necessary to safeguard crew or vessel.

Where venting of ammonia is necessary for safety reasons, systems are to be designed to minimize the accumulation of gas released to the open space and to facilitate dispersion into the atmosphere so that minimum safe flammable and toxicity levels can be maintained within acceptable distances from the vent mast or riser location.

In addition, anhydrous ammonia is extremely harmful to aquatic life. Direct discharge to seawater is to be avoided unless otherwise approved by the Administration.

2.10

Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.

2.11

Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

2.12

Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.

2.13

Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.

2.14

Fixed gas detection suitable for all spaces and areas concerned shall be arranged.

2.15

Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.

2.16

Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.

2.17

The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.

2.18

A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.

2.19

Personnel Protective Equipment (PPE), together with emergency treatment facilities, appropriate to the hazards concerned (in particular toxicity), for operational and maintenance purposes, are to be provided.

2.20 *(1 September 2023)*

Emergency escape equipment, appropriate to the hazards concerned (in particular toxicity), are to be provided for each person onboard.

SECTION 4
General Provisions

1 Goal

The goal of this Section is to outline the necessary assessments of the risks involved which should be carried out in order to eliminate or mitigate any adverse effect to the persons on board, the environment, or the ship.

2 Risk Assessment

2.1

A risk assessment is to be conducted to address the risks arising from the use of anhydrous ammonia as fuel affecting persons on board, the environment, the structural strength or the integrity of the ship. Consideration is to be given to the hazards associated with design, layout, operation and maintenance, following any reasonably foreseeable failure. In particular, the risks to the crew and the environment from the toxicity of ammonia releases is to be considered.

2.2 *(1 September 2023)*

The risks are to be analyzed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion, toxicity and corrosiveness of ammonia and electric shock are as a minimum to be considered. The analysis is to seek to minimize or eliminate risks wherever possible. Risks which cannot be eliminated are to be mitigated as necessary (to an acceptable level of safety). Details of risks, and the means by which they are mitigated, are to be documented in a report and submitted for review.

Commentary:

See IACS Recommendation No.146, Risk Assessment as required by the IGF Code. See also the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* for further guidance on risk assessment.

End of Commentary

2.3 *(1 September 2023)*

The risk assessment is to specifically consider, but not limited to the items in this document and Chapter 5C-13 of the *Marine Vessel Rules* as referenced below:

i) Required number of compressed air safety equipment sets – see 5/11.4

ii) Duration of the EEBDs – see 5/11.7

iii) Number of, persons and location of, machinery space emergency escape equipment – see 5/11.7

iv) The toxic areas identified by Subsection 12/6 of this document, including arrangements and access for LSA equipment, muster stations and escape routes. For those vessels not equipped with

enclosed lifeboats equipped with self-contained air support systems (as required by SOLAS Chapter III Regulation 31.1.6), the risk assessment is to consider the need for enclosed lifeboats to be equipped with selfcontained air support in accordance with Chapter IV, 4.8 of the Life-Saving Appliances Code

v) Arrangements for fuel preparation rooms, tank connection spaces and FVT spaces/enclosures – see 9/5.10 and 12/6.6

vi) Arrangement of drain tank(s) and capacity of drip trays – see 5/8.6 of this document and 5C-13-5/10.5 of the *Marine Vessel Rules*

vii) Arrangement and capacity of the fuel treatment and vent control system – see 9/5.1

viii) Arrangements of airlocks and airlock access to the spaces containing potential source of ammonia release/leakage – see 5C-13-5/12.3 of the *Marine Vessel Rules*

ix) Evaluation of the fuel tank location and the arrangement of the fuel containment system – see 6/7.2 of this document and 5C-13-6/4.1.1 of the *Marine Vessel Rules*

x) Arrangements of enclosed or semi-enclosed bunker stations – see 8/4.2 & 11/6 & 13/6 of this document and 5C-13-8/3.1.1 and 5C-13-13/7 of the *Marine Vessel Rules*

xi) Evaluation of the combined ventilation systems serving the spaces with source of ammonia release/leakage - see 13/4.1

xii) Evaluation of approval and installation of main and auxiliary boilers using ammonia as fuel – see 10/5

xiii) Gas detection and closing arrangements of the air intakes and other openings into the accommodation spaces, service spaces and control stations – see 13/3.3 of this document and 5C-13-15/8.1.10 of the *Marine Vessel Rules*

xiv) The need for additional quantitative analysis, such as gas dispersion study, to support the design approval and the items identified by 6/6.1, 12/6.2, 12/6.8 and 15/Table 1

2.4 *(1 September 2023)*

The risk assessment plan is to be submitted to ABS for review prior to conducting the risk assessment, and is to contain, but is not limited to:

i) Description of proposed Function

ii) Quantitative or Qualitative Risk assessment method(s) to be used and description if using a nonstandard method

iii) Scope and objectives of the assessment

iv) Subject matter experts/participants/risk analysts, including their background and area of expertise

v) Proposed risk acceptance criteria or risk matrix

vi) Risk control and management measures

Further guidance on submitting a risk assessment plan can be found in the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*.

3 Limitation of Explosion Consequences *(1 September 2023)*

Consequences of an explosion in a space containing any potential source of release/leakage of flammable/toxic vapor/liquid and potential ignition sources are to be limited as listed in 5C-13-4/3 of the *Marine Vessel Rules*.

Commentary:

Double wall fuel pipes are not considered as potential sources of release.

End of Commentary

SECTION 5

Ship Design and Arrangement

1 Goal

The goal of this Section is to provide guidance for the location, space arrangements and mechanical protection of power generation equipment, fuel storage systems, fuel supply equipment and refueling systems.

2 Functional Requirements

The functional requirements of Subsection 3/2 of this document and 5C-13-5/2 of the *Marine Vessel Rules* are applicable.

3 General Provisions

The fuel containment protection requirements of 5C-13-5/3 of the *Marine Vessel Rules* are applicable.

4 Machinery Space (Engine Room) Arrangements

4.1

A single failure within the fuel system is not to lead to a release of fuel into the machinery space. Therefore, the gas safe machinery concept of 5C-13-5/4.1.1 of the *Marine Vessel Rules* is to be applied to all machinery spaces containing ammonia consumers.

Commentary:

The IGF Code 'ESD machinery space' concept is not to be applied for ammonia as fuel installations. Accordingly, all Chapter 5C-13 references from this document, that may include the 'ESD machinery space' concept requirements, are not applicable.

End of Commentary

4.2

All fuel piping within machinery space boundaries is to be enclosed in gas and liquid tight enclosures in accordance with 5C-13-9/6 of the *Marine Vessel Rules*.

4.3

Machinery spaces containing ammonia as fuel consumers are to be arranged for remote monitoring in accordance with the **ACC**, **ACCU** or **ABCU** requirements of the *Marine Vessel Rules*.

5 Location and Protection of Fuel Piping *(1 September 2023)*

Fuel pipes are to be located and protected in accordance with 5C-13-5/7.1 to 5C-13-5/7.3 of the *Marine Vessel Rules*.

Commentary:

Fuel piping addressed in this subsection include ammonia fuel piping and any other piping which may contain ammonia. e.g. fuel bleed or purge lines, relief pipes, vent pipes (except open ended pipes led to open air), etc.

End of Commentary

6 Fuel Preparation Room *(1 September 2023)*

6.1 *(1 September 2023)*

Fuel preparation rooms which may contain potential sources of release/leakage, such as single wall piping, seals on rotating equipment, instrument connections and valves, etc., are considered as hazardous and toxic spaces and are normally unmanned.

6.2 *(1 September 2023)*

Fuel preparation rooms are to be designed to safely contain fuel leakages. The boundaries of the rooms including the ventilation trunks, pipe and cable penetrations are to be gastight.

6.3 *(1 September 2023)*

The material of the boundaries of the fuel preparation room is to have a design temperature corresponding with the lowest temperature it can be subjected to in a probable maximum leakage scenario unless the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection.

6.4

When located on deck, fuel preparation rooms are to be protected against mechanical damage where vessel cargo handling operations increase the risk of mechanical impact damage.

6.5 *(1 September 2023)*

Fuel preparation rooms are to be designed to withstand the maximum pressure build up, or vacuum, during leakages or activation of the safety systems. Alternatively, an adequate ventilation system to prevent the compartment against over-pressurizing, a blow-out hatch panel or a pressure/vacuum relief venting system led to a safe location can be provided for this purpose.

6.6

Where ammonia is heated or cooled, the heating or cooling medium is to be utilized in an independent, closed system.

7 Tank Connection Space *(1 September 2023)*

7.1

Tank connection space is a space surrounding all tank connections and valves that having the connections in enclosed spaces. Tank connection spaces may also be required for tanks on open decks where the restriction of toxic areas is safety critical. Tank connection spaces may also be necessary in order to provide environmental protection for the tank connections and equipment.

7.2

A tank connection space, where the equipment such as vaporizers or heat exchangers are contained, is not regarded as fuel preparation room. Such equipment in the space is considered to only contain potential sources of release, but not sources of ignition.

7.3

Tank connection spaces are to be designed to safely contain fuel leakages. The boundaries including ventilation trunks, pipe and cable penetrations are to be gastight. In addition, the material of the bulkheads of the tank connection spaces is to have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario.

8 Bilge System for Spaces Containing Potential Source of Release *(1 September 2023)*

8.1

Design and arrangements of bilge systems for diluted ammonia are to be in accordance with 5C-13-5/9 of the *Marine Vessel Rules* in addition to the following requirements.

8.2

Design and arrangements of drip trays, as applicable to ammonia, are to be in accordance with 5C-13-5/10 of the *Marine Vessel Rules*.

8.3

The deck plating is to be arranged to facilitate easy cleaning and drying. No other plating above the deck is to be provided.

8.4 *(1 September 2023)*

The draining and pumping arrangements are to be such as to prevent the build-up on free surfaces. The drainage system is to be sized to remove not less than 125% of the capacity of either the water screen, deluge or water spray system, whichever has the greater capacity. This can apply to any space containing potential source of ammonia release/leakage and any adjacent compartment where the contaminated water may accumulate.

8.5 *(1 September 2023)*

Bilge water from the spaces including the drains from water spray, deluge or water screen systems are to be collected into independent drain tank(s) before disposal ashore, or arranged for further processing and treatment in accordance with the levels set by the Administration before discharge at sea. Dissolved ammonia (i.e. aqueous ammonia with concentration 28% or less) collected in the drain tank(s) may be discharged at sea complying with the standards and operational procedures required in MARPOL 73/78, Annex II.

8.6 *(1 September 2023)*

Drain tank(s) is to be arranged in accordance with 5C-9-15/12.3 of the *Marine Vessel Rules*. In addition, the tank(s) is to be located outside the machinery spaces with the vent piping leading to a safe area on an open deck. The location, arrangement and capacity of the tank(s) are to be further evaluated during the risk assessment required by 4/2.3.

8.7 *(1 September 2023)*

Piping system and the tanks serving to the drainage system are to be made of a suitable material complying with the provisions of Section 7.

9 Arrangement of Entrances and Other Openings in Enclosed Spaces

9.1

Arrangements of entrances and other openings in enclosed spaces are to be in accordance with 5C-13-5/11.1 through 5C-13-5/11.3 and 5C-13-5/11.5 of the *Marine Vessel Rules*.

9.2 *(1 September 2023)*

Unless permitted by SOLAS Chapter II-2, Regulation 13.2, a minimum of two widely separated means of escape are to be provided for the fuel preparation rooms and tank connection spaces, except where;

i) only bolted hatch access is arranged, or

ii) for small compartments that are entered only occasionally and have less than 5 m distance to the access door.

Water screens outside the access doors and operable manually from outside the compartment are to be provided in accordance with Section 15 of this document.

One of the means of escape may be a vertical ladder through a hatch to the weather deck. In this case, a water deluge system that covers the area of the hatch and entrance to any ladder trunk is to be provided in lieu of the water screen. Both water screen and water deluge systems, as applicable, are to be designed to maintain the continuous operation for a period of 30 minutes or more.

9.3 *(1 September 2023)*

The door sills of fuel preparation rooms and tank connection spaces are to be arranged with a minimum height of 300 mm or a height sufficient to contain the liquid resulting from the maximum leakage calculated, whichever is greater.

9.4 *(1 September 2023)*

Access to the fuel preparation rooms and, as applicable to the tank connection spaces is to be provided with proper locking arrangements. Relevant warning notices for safe entry are to be posted adjacent to the entrances.

9.5 *(1 September 2023)*

Unless access to the fuel storage hold and/or interbarrier spaces is independent and direct from open deck, it is to be arranged as a bolted hatch and located at the top of the space.

9.6 *(1 September 2023)*

Fuel valve trains (FVT) may be located on an open deck or within engine rooms or fuel preparation rooms. Where FVT is in an engine room, it is to be arranged as an enclosure access through a bolted hatch or fitted within a dedicated compartment accessed through an air lock. Opening of the FVT access hatches is only permitted when the fuel supply system is shut down and the system is free of ammonia liquid or vapor.

10 Airlocks

Airlocks are to be in accordance with 5C-13-5/12 of the *Marine Vessel Rules*.

11 Personnel Safety and PPE

11.1 *(1 September 2023)*

Suitable gas tight protective equipment consisting of large aprons, special gloves with long sleeves, suitable footwear, coveralls made of chemical-resistant material, and face shields manufactured to a recognized national or international standard is to be provided for protection of crew members engaged in normal bunkering operations or fuel system maintenance and operation. The protective clothing and equipment should cover the crew's entire body without any exposed skin.

11.2

Personal protective and safety equipment required in this section is to be kept in suitable, clearly marked lockers located in readily accessible places.

11.3

The compressed air equipment is to be inspected at least once a month by a responsible officer and the inspection logged in the ship’s records. Also, this equipment is to be inspected and tested by a competent person at least once a year.

11.4

A minimum of three complete sets of safety equipment are to be provided in addition to the required firefighter's outfits. The risk assessment required by 4/2.3 is to specifically consider the need for additional sets. Each set is to provide adequate personal protection to permit entry and work in a gas-filled space.

11.5 *(1 September 2023)*

Each complete set of safety equipment is to consist of:

i) one self-contained positive pressure air-breathing apparatus incorporating full face mask not using stored oxygen and having a capacity of at least 1,200 ℓ (liters) of free air. Each set is to be compatible with the required firefighter's outfits.

ii) protective gas tight clothing (without any exposed skin), boots and gloves manufactured to a recognized standard.

iii) steel-cored rescue line with belt.

iv) lamp with proper hazardous area rating.

11.6

An adequate supply of compressed air is to be provided and is to consist of:

i) at least one fully charged spare air bottle for each breathing apparatus required by 5/11.4,

ii) an air compressor of adequate capacity capable of continuous operation, suitable for the supply of high-pressure air of breathable quality and

iii) a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by 5/11.4.

11.7 *(1 September 2023)*

Suitable respiratory and eye protection for emergency escape purposes is to be provided for every person on board subject to the following:

i) filter type respiratory protection is not acceptable.

ii) self-contained breathing apparatus is to have at least a duration of service of at least 15 min; and

Commentary:

The risk assessment required by 4/2.3 is to specifically consider the need for additional duration.

End of Commentary

iii) emergency escape respiratory protections are not used for firefighting or fuel handling purposes and are to be marked to that effect.

Adequate emergency escape equipment for respiratory and eye protection is to be located at sufficient locations within the space to support personnel escape in the event of a fuel leak to the space. The risk assessment required by 4/2.3 is to consider the numbers and location of this equipment. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. Such equipment locations are to be clearly marked with signboards and the emergency escape procedures detailed in the operational procedures, emergency escape and safety plans.

11.8

Eyewash and decontamination safety showers are to be provided, the location and number of these eyewash stations and safety showers are to be derived from the detailed installation arrangements. As a minimum, the following stations are to be provided:

i) In the vicinity of the fuel preparation room(s), fuel transfer or treatment pump locations. If there are multiple fuel transfer or treatment pump locations on the same deck, one eyewash and safety shower station may be considered for acceptance provided that the station is easily accessible from all such pump locations on the same deck.

ii) An eyewash station and safety shower are to be provided in the vicinity of a fuel bunkering station on-deck. If the bunkering connections are located on both port and starboard sides, then consideration is to be given to providing two eyewash stations and safety showers, one for each side.

iii) An eyewash station and safety shower are to be provided in the vicinity of any part of the fuel system where the potential for a person to come into contact with ammonia exists (e.g., openings such as filling/drainage or system connections/components or tank connections, etc. that require periodic maintenance).

iv) The eyewash stations and decontamination showers are to be operable in all ambient conditions.

11.9

The ship is to be provided with at least two sets of portable ammonia gas detectors that meet an acceptable national or international standard.

SECTION 6

Fuel Containment System

1 Goal

The goal of this Section is to provide that gas storage is adequate so as to minimize the risk to personnel, the ship and the environment to a level that is equivalent to a conventional oil fueled ship.

2 Functional Requirements

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-6/2 of the *Marine Vessel Rules* are applicable.

3 General

The general fuel containment requirements of 5C-13-6/3.2 through 5C-13-6/3.12 of the *Marine Vessel Rules*, as applicable to the storage of ammonia, apply.

4 Fuel Containment

4.1

Fuel storage tanks are to be designed in accordance with Section 5C-8-4 of the *Marine Vessel Rules* for liquefied or pressurized ammonia fuel containment.

4.2

The fuel storage tank design life is not to be less than the design life of the ship or 20 years, whichever is greater.

4.3

The fuel storage tank types defined in 5C-8-4/21 to 5C-8-4/26 of the *Marine Vessel Rules* are to be provided with secondary barriers in accordance with the following table.

Basic Tank Type	*Secondary Barrier*
Membrane	Complete Secondary Barrier
Type A	Complete Secondary Barrier
Type B	Partial Secondary Barrier
Type C	No Secondary Barrier

4.4

Anhydrous ammonia may, under certain conditions, cause stress corrosion cracking in containment and process systems constructed from susceptible materials. To minimize the risk of this occurring in carbon manganese and nickel steels, specific measures detailed in 5C-8-17/12.2 to 5C-8-17/12.8 of the *Marine Vessel Rules* are to be taken, as appropriate.

4.5

Materials of construction such as aluminum and austenitic stainless steel may be applied in ammonia service as permitted by Section 5C-13-7 of the *Marine Vessel Rules*. Subject to review and agreement of ABS, other materials may be considered for ammonia service provided they meet design criteria, are suitable at the service temperatures, and sufficient corrosion data and environmental cracking susceptibility data exists.

4.6 *(1 September 2023)*

Ship's hull as secondary barrier is to be constructed with suitable material to be compatible with the cargo in accordance with 5C-8-4/6 of the *Marine Vessel Rules*.

5 Portable Tanks

Portable fuel tanks are to be arranged in accordance with 5C-13-6/5 of the *Marine Vessel Rules*.

6 Pressure Relief Systems

6.1 *(1 September 2023)*

Pressure relief valves and systems in accordance with 5C-13-6/7.1 to 7.3 of the *Marine Vessel Rules* are to be provided.

6.2

Other than when necessary for safety reasons, the pressure control and relief system is to be designed to prevent venting under all operating conditions including idle periods.

6.3

Pressure relief discharges are to be through the vent mast. Vent masts are to be equipped with fixed ammonia gas detection and monitored in accordance with Section 15.

6.4

Fuel storage hold spaces, interbarrier spaces, tank connection spaces and tank cofferdams, which may be subject to pressures beyond their design capabilities, are to be provided with a suitable pressure relief system that vents to the hazardous area vent mast or riser location. These pressure relief systems are to be independent of the fuel control systems specified in 6/8.1.

7 Filling and Loading Limit for Fuel Tanks

7.1

Fuel storage tanks for liquefied gas are not to be filled to more than 98% full, relative to the total tank volume, when the fuel has reached the reference temperature.

7.2 *(1 September 2023)*

The maximum loading limit (LL) to which a fuel tank may be loaded is to be determined in accordance with the formula given in 5C-13-6/8.1 or alternatively, 5C-13-6/8.2 of the *Marine Vessel Rules*. A loading limit curve for the actual fuel loading temperatures is to be prepared.

8 Maintaining Fuel Storage Condition

8.1

With the exception of liquefied gas fuel tanks designed to withstand the full gauge vapor pressure of the fuel under conditions of the upper ambient design temperature, liquefied gas fuel tanks' pressure and temperature are to be maintained at all times within their design range in accordance with 5C-13-6/9.1 and 5C-13-6/9.4 of the *Marine Vessel Rules*.

The 15 day criteria for maintaining tank pressure below the set pressure of the relief valve detailed under 5C-13-6/9.1 of the *Marine Vessel Rules*, is to be considered at all tank fill conditions.

8.2

Venting of fuel vapor for control of the tank pressure is not acceptable except in emergency situations.

8.3

The design and availability of systems for maintaining fuel storage condition are to be in accordance with 5C-13-6/9.2 and 5C-13-6/9.6 of the *Marine Vessel Rules*.

8.4 *(1 September 2023)*

A vapor return line for pressure management during bunkering operations is to be provided unless the ammonia fuel is bunkered under fully pressurized condition at ambient temperature. Alternative arrangements for pressure management may also be considered.

9 Atmospheric Control Within the Fuel Containment

Provision to enable each fuel tank to be gas-freed are to be provided in accordance with 5C-13-6/10 of the *Marine Vessel Rules*.

10 Atmospheric Control Within Fuel Storage Hold Spaces

10.1

Atmospheric control arrangements for interbarrier and fuel storage hold spaces associated with liquefied gas fuel containment systems requiring full or partial secondary barriers (fuel containment systems other than Type C), are to be in accordance with 5C-13-6/11 of the *Marine Vessel Rules*.

10.2

Atmospheric control arrangements for fuel storage hold spaces surrounding Type C independent tanks are to be in accordance with 5C-13-6/12 of the *Marine Vessel Rules*.

11 Inert Gas Arrangements

11.1

Inert gas arrangements are to be in accordance with 5C-13-6/13 of the *Marine Vessel Rules*.

11.2

Where inert gas is produced on board, the production and storage arrangements are to be in accordance with 5C-13-6/14 of the *Marine Vessel Rules*.

11.3 *(1 September 2023)*

The use of inert gas other than nitrogen for the fuel containment may be considered on a case by case basis.

12 Reliquefaction and Refrigeration Systems

12.1 *(1 September 2023)*

The dedicated fuel reliquefaction and refrigeration systems used to maintain fuel tanks' pressure and temperature are to be designed in accordance with 5C-13-6/9.3 and 5C-13-6A2 of the *Marine Vessel Rules*.

12.2

Refrigerants or auxiliary agents used in reliquefaction or refrigeration systems, or for cooling of fuel are to be compatible with the fuel they may come in contact with (not causing any hazardous reaction or excessively corrosive products). In addition, when several refrigerants or agents are used, these are to be compatible with each other.

SECTION 7

Material and General Pipe Design

1 Goal

The goal of this Section is to outline the requirements for the handling of fuel, under all operating conditions, to minimize the risk to the ship, personnel and to the environment, having regard to the nature of the products involved.

2 Functional Requirements

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-7/2 of the *Marine Vessel Rules* are applicable.

3 General Pipe Design

Fuel pipe design and arrangements are to be in accordance with 5C-13-7/3 of the *Marine Vessel Rules*.

4 Materials

4.1

Materials in general are to comply with the requirements of the ABS *Rules for Materials and Welding (Part 2)*.

4.2 *(1 September 2023)*

Materials for fuel containment, fuel piping, process pressure vessels are to be in accordance with 5C-13-7/4 of the *Marine Vessel Rules* and where applicable, 7/4.4 of this document.

Commentary:

The use of alternative metallic materials may be used for ammonia service subject to IMO Guidelines MSC.1/Circ.1622, as amended by MSC.1/Circ/1648.

End of Commentary

4.3

Materials that may be directly exposed to ammonia during normal operations are to be resistant to the corrosive actions and environmentally assisted cracking associated with ammonia service.

4.4

Anhydrous ammonia may, under certain conditions, cause stress corrosion cracking in containment and process systems constructed from susceptible materials. To minimize the risk of this occurring in carbon

manganese and nickel steels, specific measures detailed in 5C-8-17/12.2 to 5C-8-17/12.8 of the *Marine Vessel Rules* are to be taken, as appropriate.

4.5

Materials of construction such as aluminum and austenitic stainless steel may be applied in ammonia service as permitted by Section 5C-13-7 of the *Marine Vessel Rules*. Subject to review and agreement of ABS, other materials may be considered for ammonia service provided they meet design criteria, are suitable at the service temperatures, and sufficient corrosion data and environmental cracking susceptibility data exists.

4.6

In addition, the following materials of construction for fuel tanks and associated pipelines, valves, fittings and other items of equipment normally in direct contact with the ammonia liquid or vapor are not to be used:

- Mercury, cadmium, copper, zinc or alloys of these materials

4.7

Components of rubber or plastic materials that are likely to deteriorate if exposed to ammonia are not to be used. Subject to review and agreement of ABS, certain rubbers and plastics may be considered for ammonia service provided they meet design criteria, are suitable at the service temperatures, aging properties are established as appropriate for the design life, and sufficient corrosion data and environmental cracking/damage susceptibility data exists.

SECTION 8
Bunkering

1 Goal

The goal of this Section is to provide for suitable systems on board the ship for bunkering to mitigate the danger to persons, the environment, or the ship.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-8/2 of the *Marine Vessel Rules* are applicable.

2.2

Bunkering systems are to be designed to prevent venting under all normal operating conditions including idle periods.

3 General

See the requirements under Subsection 5/11 for ammonia bunkering PPE requirements.

4 Bunkering Station

4.1

Fuel bunkering station arrangements are to be in accordance with 5C-13-8/3 of the *Marine Vessel Rules*.

4.2 *(1 September 2023)*

Where enclosed or semi-enclosed bunkering stations are permitted, water screen systems as detailed in 5/9.3 are to be provided for the access doors to mitigate the risk of ammonia vapor passing to other spaces on the vessel. The arrangement may be further considered during the risk assessment required by 4/2.3.

5 Bunkering Manifold *(1 September 2023)*

Fuel bunkering manifold arrangements are to be in accordance with 5C-13-8/4 of the *Marine Vessel Rules*.

6 Bunkering System

6.1

Fuel bunkering system arrangements are to be in accordance with 5C-13-8/5 of the *Marine Vessel Rules*.

6.2 *(1 September 2023)*

The closing time of the shutdown valves is to be calculated as per 5C-13-16/7.3.7 of the *Marine Vessel Rules*, but cannot be more than 5 seconds from receiving shutdown signal to full closure of the valve, unless surge pressure consideration requires a longer closing time. When automatic shutdown is activated by high-level alarm in the tank, the closing time of the valve is to be sufficient to prevent overfilling.

Commentary:

The requirement may also be applicable to the tank filling valves if automatic operation is activated by high-level alarm in the tank during transfer operation between fuel tanks.

End of Commentary

7 Gas Detection

All bunker stations and ventilated ducts, or double wall piping systems, around fuel bunker pipes are to be fitted with permanently installed gas detectors or leak detection, suitable for flammability and toxicity, in accordance with Subsection 15/8.

Monitoring and safety system functions are to be provided in accordance with Section 15.

SECTION 9

Fuel Supply to Consumers

1 Goal

The goal of this Section is to outline the requirements for the distribution of fuel to the consumers.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-9/2 of the *Marine Vessel Rules* are applicable.

2.2

Fuel supply systems are to be designed to prevent venting under all normal operating conditions including idle periods.

3 General

3.1 *(1 September 2023)*

The requirements specified in this Section are intended to cover the fuel supply arrangements and systems fitted on board to deliver ammonia from the fuel tank to the prime movers and consumers. Fitted arrangements and systems will vary from vessel type to vessel type and from prime mover to prime mover and hence may for example include compressors, process skids or fuel preparation equipment, etc. Dependent on the specific arrangements reference may also need to be made to the requirements for reliquefaction components and systems given under Subsection 6/12.

3.2

The fuel piping system for ammonia is to be independent from all other fuel piping systems.

4 Redundancy of Fuel Supply *(1 September 2023)*

4.1 *(1 September 2023)*

Fuel supply redundancy arrangements are to be in accordance with 5C-13-9/3 of the *Marine Vessel Rules* as applicable to ammonia fuel systems.

4.2

Propulsion and power generation arrangements, together with fuel supply systems, are to be arranged so that a failure in fuel supply does not lead to an unacceptable loss of power.

5 Safety Functions of the Fuel Supply System

5.1 *(1 September 2023)*

Fuel supply systems are to be designed to prevent venting, except where necessary for safety and emergency reasons, so that ammonia releases from the fuel system can be returned back to fuel system or fuel storage tank or to be led to a treatment system. Fuel treatment or vent control system is to be capable of collecting and handling liquid or gaseous ammonia from normal operation or any upset situation of the system, i.e. vent or bleeding operations from double block and bleed valves, purging, draining and gas-free operations of fuel pipes, vents from knock-out drums and releases from pressure relief valves fitted on ammonia fuel piping. Vent scrubbers or knock-out drums may be provided prior to discharge the ammonia to the treatment system.

The fuel treatment or vent control system is to reduce the concentration of ammonia below 25 ppm prior to discharge to vent mast or riser location. In addition, the capacity of the system is to be suitable considering the largest possible amount of ammonia released from the fuel supply systems. The capacity of the system is subject to further evaluation during the risk assessment required by 4/2.3.

5.2 *(1 September 2023)*

All pipelines or components which may be isolated in a liquid full condition are to be provided with thermal relief valves. The vent lines from the valves are to be led to the vent mast, or alternatively could be diverted to the fuel treatment or vent control system, as far as practicable.

5.3 *(1 September 2023)*

All fuel piping arrangements are to allow for purging and inerting. The inert gas system connection to the fuel system is to be arranged in accordance with the requirements in Subsection 6/11.

5.4 *(1 September 2023)*

Where the fuel treatment or vent control systems as per 9/5.1 utilize water scrubbing or treatment systems, these are to be arranged to be independent of other water treatment or bilge systems and arranged to collect residues or contaminated water in holding tanks for further processing or disposal ashore.

5.5

Fuel storage tank inlets and outlets are to be provided with valves located as close to the tank as possible. Valves required to be operated during normal operation which are not accessible are to be remotely operated. Tank valves whether accessible or not are to be automatically operated when the safety system required in Section 15 is activated.

Commentary:

Normal operation in this context is when fuel is supplied to consumers and during bunkering operations.

End of Commentary

5.6

Tank valves are to be remotely operated, be of the fail closed type (closed on loss of actuating power), are to be capable of local manual closure, and have positive indication of the actual valve position.

5.7

The main fuel supply lines to each consumer or set of consumers is to be equipped with a manually operated stop valve and an automatically operated "master fuel valve" coupled in series or a combined manually and automatically operated valve. The valves are to be situated in the part of the piping that is outside the machinery space containing the consumers. The master fuel valve is to automatically shut off the fuel supply when activated by the safety system required in Section 15.

5.8 *(1 September 2023)*

If the master fuel valve is located in an enclosed space such as a fuel preparation room, that space is to be protected against fuel leakage by another automatic shutdown valve arranged for closure in the event that gas or leakage is detected within the enclosed space, or loss of ventilation for the duct or casing of the double wall fuel piping occurs. That additional automatic shutdown valve may be the fuel tank outlet valve required by 9/5.5.

5.9

The automatic master fuel valve to the consumers, or set of consumers, is to be operable

i) from safe location on the primary escape route from the engine room

ii) secondary escape route from the engine room

iii) at a location outside the engine room(s)

iv) outside the fuel preparation room

v) at the engine control room and

vi) at the navigation bridge.

The activation device is to be arranged as a physical button, duly marked and protected against inadvertent operation and operable under emergency lighting.

5.10 *(1 September 2023)*

Each consumer is to be provided with "double block and bleed" valves arrangement at ammonia fuel supply and return lines, as applicable. These valves are to be arranged as outlined in *i)* or *ii)* below, so that when the safety system required in Section 15 is activated this will cause the shutoff valves that are in series to close automatically and the bleed valve to open automatically. Also:

i) the two shut-off valves are to be in series in the fuel pipe to the consuming equipment. The bleed valve is to be in a pipe that vents to the fuel return system that portion of the fuel piping that is between the two valves in series; or

ii) the function of one of the shutoff valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the consumer will be blocked and the vent line opened.

The two shut-off (block) valves are to be of the fail-to-close type, while the bleed valve is to be fail-to-open.

The parts of the fuel supply system that incorporate the “double block and bleed” valve arrangement, typically known as Fuel Valve Train (FTV), may be located in a dedicated space or double barrier enclosure. In such cases they are to be arranged in accordance with 5C-13-10/3.1.15 of the *Marine Vessel Rules* and are to be considered by the risk assessment required by 4/2.3.

5.11

The double block and bleed valves are also to be used for normal stop of the consumer.

5.12

An automatic purge is to be activated upon automatic closure of the master fuel valve. Arrangements are to be such that the piping between the master fuel valve and the consumer will be automatically purged with inert gas.

5.13

There is to be one manually operated shutdown valve in the fuel supply line to each consumer upstream of the double block and bleed valves to provide isolation during maintenance.

5.14 *(1 September 2023)*

Where a separate master fuel valve is provided for each consumer, the master fuel valve and the double block and bleed valve functions can be combined.

Commentary:

The combined master fuel valve and block valve are to be located outside the machinery space, as required by 9/5.7. Where such valves are located in a fuel preparation room, that room is to be protected by another automatic shutdown valve outside the room and as required by 9/5.8.

End of Commentary

5.15

The transient response characteristics of the fuel supply and control systems are to be such that transient variations in fuel demand would not cause unintended shutdown of the fuel supply system.

5.16 *(1 September 2023)*

As applicable, where the auxiliary heat exchange circuits are likely to contain ammonia in abnormal conditions as a result of a component failure (refer to FMEA for more information and 10/3.1), they are to be arranged with means to detect leakage. Alarm is to be given when the presence of ammonia is detected.

Auxiliary circuits are to be arranged in a closed system with pressure protection. Vent pipes are to be independent and to be led to the vent mast or a safe location in the open air.

5.17 *(1 September 2023)*

Expansion bellows are not to be used in ammonia fuel piping systems.

6 Fuel Distribution Outside of Machinery Spaces

6.1

Fuel piping systems outside of machinery spaces are to be arranged in accordance with 5C-13-9/5 of the *Marine Vessel Rules*.

6.2 *(1 September 2023)*

Fuel piping in the fuel preparation rooms and tank connection spaces complying with the requirements of this document is not required to be arranged with a secondary enclosure. In addition, fully welded bunkering lines on open deck may be also arranged single walled when located on the open deck.

6.3 *(1 September 2023)*

Drip trays, spray shields, or equivalent means designed to avoid accumulation of ammonia gas with suitable drainage line, are to be arranged for all leakage points of fuel piping not protected by secondary enclosure. Collected ammonia from the leakages is to be drained to the ammonia drain tank.

6.4 *(1 September 2023)*

Except in refrigerated ammonia fuel systems, liquid ammonia piping is to be designed as a minimum at pressure of 1.8 MPa, considering the vapor pressure of ammonia at 45℃. In addition, pressure in the fuel system is to be sufficient to maintain the fuel in the liquid state, where ammonia fuel is intended to be used in the liquid state.

6.5 *(1 September 2023)*

Gaseous ammonia fuel supply piping system are to be sufficiently heated to maintain the gaseous phase until supplying to the consumers. The monitoring and control system to maintain the fuel in gaseous state

is to be arranged covering the monitoring of fuel temperature, pressure, and heating system subject to the engine safety concept and the risk assessment.

7 Fuel Supply in Gas Safe (Non-Hazardous) Machinery Spaces

Fuel piping systems in gas safe machinery spaces containing consumers are to be arranged in accordance with 5C-13-9/6 of the *Marine Vessel Rules*.

8 Design of Fuel Piping Ventilated Duct or Outer Pipe

The design of the fuel piping ventilated duct or outer pipe is to be in accordance with 5C-13-9/8 of the *Marine Vessel Rules*.

9 Compressors and Pumps *(1 September 2023)*

Compressors and pumps are to be in accordance with 5C-13-9/9 of the *Marine Vessel Rules*.

10 Vaporizers, Heat Exchangers and Pressure Vessels

Vaporizers, heat exchangers and pressure vessels are to be arranged, as applicable, in accordance with 5C-13-9/10 of the *Marine Vessel Rules*.

11 Ancillary Systems

The design of the fuel supply ancillary systems is to be in accordance with 5C-13-9/12 of the *Marine Vessel Rules*.

SECTION **10**

Power Generation Including Propulsion and Other Energy Converters

Commentary:

The requirements specified in this section are additional to all other relevant requirements of the *Marine Vessel Rules*.

End of Commentary

1 Goal

The goal of this Section is to provide requirements for the delivery of mechanical, electrical or thermal energy.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-10/2 of the *Marine Vessel Rules* are applicable.

2.2

Engine fuel systems are to be designed to prevent venting under all normal operating conditions including idle periods.

3 General *(1 September 2023)*

3.1

Internal combustion engines intended to burn ammonia as fuel are to be designed, tested and certified in accordance with Sections 4-2-1, 5C-8-16 and 5C-13-10, as applicable, of the *Marine Vessel Rules*.

The fuel specification required by the engine is to be declared by the manufacturer and detailed in the operation and maintenance manuals.

3.2 *(1 September 2023)*

Internal combustion engines, and as applicable, associated exhaust aftertreatment systems, are to be designed to minimize the ammonia release through the exhaust outlet(s) to prevent health hazard and remain within the acceptable limits set by any national and/or international authority or administration, as applicable.

Where selective catalytic reduction (SCR) exhaust aftertreatment equipment is installed to meet NOx emissions limits, or NH_3 safe limits, with or without dedicated NH_3 control catalysts, the arrangements are to be in accordance with Part 6, Chapter 3 of the *Marine Vessel Rules*.

Monitoring of exhaust(s) is to be in accordance with Section 15 of this document.

Commentary:

Engine specifications and manufacturer recommendations should be considered for the ammonia slip through the engine exhaust and any available exhaust gas treatment options. Note that acceptable ammonia slip limits should be documented for any engine load points and presented in the NOx Technical File.

End of commentary

3.3 *(1 September 2023)*

All engines except for the two-stroke crosshead types are to be fitted with independent vent systems for crankcases and sumps that are separated from other engine's vent systems. Gas extracted from the crankcase and sumps is to be led through the fuel treatment or vent control system to avoid ammonia release to the atmosphere.

Monitoring of crankcase breather(s), or under piston space(s), is to be in accordance with Section 15.

3.4

The design of internal combustion engines is to be in accordance with 5C-13-10/1.1, 5C-13-10/3.1.1 through 5C-13-10/3.1.3 and 5C-13-10/3.1.5 through 5C-13-10/3.1.7, as applicable, of the *Marine Vessel Rules*.

3.5

The engine transient response characteristics are to be appropriate for the intended application. Engines driving generators are to meet the transient response requirements of 4-2-1/7.5 of the *Marine Vessel Rules*, however, consideration may be given to the use of alternative performance criteria such as ISO 8528 where appropriately matched with the vessel power management system.

3.6

Engine air inlet manifolds and crankcases are to be arranged in accordance with 5C-13-10/3.1.12 and 5C-13-10/3.1.13 of the *Marine Vessel Rules*.

3.7

A Failure Modes and Effects Analysis (FMEA) is to be carried out by the engine manufacturer in order to determine necessary additional safeguards to address the hazards associated with the use of ammonia as a fuel, for example, protection against explosion, cylinder overpressure, etc.. This requirement is in addition to, but may be included by revision of, the FMEA required by 4-2-1-A1/9.11 TABLE 1 of the *Marine Vessel Rules*.

The analysis is to identify all plausible scenarios of fuel leakage and the resulting hazards. Then the analysis is to identify necessary means to control the identified hazards.

4 Dual Fuel Engines

4.1

Dual fuel internal combustion engines are to be arranged in accordance with 5C-13-10/3.2 of the *Marine Vessel Rules*.

4.2 *(1 September 2023)*

Dual fuel internal combustion engine type testing is to include verification of the exhaust and crankcase breather, or under piston space, limits of 10/3.3.

5 Main and Auxiliary Boilers *(1 September 2023)*

Where ammonia is used as fuel for the dual fuel main and auxiliary boilers that are arranged in accordance with 5C-13-10/4 of the *Marine Vessel Rules*, are to be specially considered and approved on a case-by-case basis. Risk assessment as required by 4/2.3 is also to cover the approval and installation of such equipment on board vessels.

6 Fuel Cells

Fuel cells are to be arranged in accordance with the ABS *Requirements for Fuel Cell Power Systems for Marine and Offshore Applications*.

SECTION 11
Fire Safety

1 Goal

The goal of this Section is to provide for fire protection, detection and fighting for all system components related to the storage, conditioning, transfer and use of ammonia as ship fuel.

2 Functional Requirements

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-11/2 of the *Marine Vessel Rules* are applicable.

3 General

3.1

The provisions in this section are additional to those in SOLAS Chapter II-2.

3.2

The fire protection requirements of 5C-13-11/3.1 through 5C-13-11/3.6 of the *Marine Vessel Rules* are applicable.

3.3 *(1 September 2023)*

Fuel preparation rooms and ventilation trunks to fuel preparation rooms are to be separated from the machinery spaces of Category A or other rooms with low and high fire risk in accordance with the requirements of 5C-13-11/3.3 of the *Marine Vessel Rules*, as applicable.

4 Fire Main

The fire main is to be arranged in accordance with 5C-13-11/4 of the *Marine Vessel Rules*.

5 Water Spray System

5.1

The water spray system is to be arranged in accordance with 5C-13-11/5 of the *Marine Vessel Rules*.

5.2 *(1 September 2023)*

In addition to the water spray system providing coverage for the fuel tanks, and the additional locations required by 5C-13-11/5.2 of the *Marine Vessel Rules*, the water spray system is also to be arranged to cover all exposed portion of the fuel piping system fitting with source of release.

5.3

The bunker manifold and bunker station area are to be protected with a water spray system and provided with a means for readily accessible remotely operated isolation valve at the bunker control station. Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system are to be located in a readily accessible position at the bunker control station.

The water spray coverage may be provided by a separate system, or may be provided by the water spray system required by 11/5.1 of this document. With respect to application of 5C-13-11/5.2 of the *Marine Vessel Rules*, the system is to be provided regardless of the distance of the bunker station from the fuel tank.

5.4 *(1 September 2023)*

Manual activation points of water spray systems are to be located in a safe area as detailed in the approved fire and safety plans.

6 Bunker Station Fire-Extinguishing System *(1 September 2023)*

The bunker station fire-extinguishing system is to be arranged in accordance with 5C-13-11/6 of the *Marine Vessel Rules*. Acceptance of alternative fire-extinguishing arrangements other than the required in the Rules is subject to further evaluation as per Subsection 2/3 and to risk assessment required by 4/2.3.

7 Fire Detection and Alarm System

7.1

The fire detection and alarm systems are to be arranged in accordance with 5C-13-11/7 of the *Marine Vessel Rules*.

7.2 *(1 September 2023)*

Smoke detectors as required under 5C-13-11/7.2 of the *Marine Vessel Rules* are to be combined with either temperature, flame or other alternative detectors to increase possibility for detection of a fire.

Commentary:

Note that the flame detectors will normally activate before temperature detectors.

End of Commentary

8 Fire Extinguishing of Engine Room, Fuel Preparation Room and Tank Connection Space *(1 September 2023)*

8.1

Machinery spaces and fuel preparation rooms where ammonia fueled engines or fuel supply systems are located are to be protected by an approved fixed fire-extinguishing system in accordance with SOLAS Chapter II-2 Regulation 10 and the FSS Code. In addition, the fire-extinguishing medium used is to be suitable for the extinguishing of ammonia fire.

8.2 *(1 September 2023)*

Tank connection spaces containing fuel pump electric motors or any other associated rotating parts are to be provided with a fixed fire-extinguishing system complying with the provisions of the FSS Code.

SECTION 12

Explosion Prevention, Area Classification and Toxic Areas

1 Goal

The goal of this Section is to mitigate the risk of explosions and for the limitation of effects from explosion.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-12/2 of the *Marine Vessel Rules* are applicable and the probability of explosions is to be reduced to a minimum by using certified safe type electrical equipment suitable for the hazardous zone, where the use of electrical equipment in hazardous areas is unavoidable.

2.2 *(1 September 2023)*

Toxic areas and the risk of ammonia vapor exposure to the persons on board are to be mitigated by reducing the number of potential leak sources, proper arrangement of the vents, ventilation and provided separation from safe spaces.

3 General

3.1 *(1 September 2023)*

The requirements of 5C-13-12/3.1 and 3.2 of the *Marine Vessel Rules* are applicable.

3.2 *(1 September 2023)*

All hazardous and toxic areas are to be inaccessible to any unauthorized person at all times.

4 Area Classification

4.1 *(1 September 2023)*

The hazardous area classification requirements of 5C-13-12/4 of the *Marine Vessel Rules* are applicable.

4.2 *(1 September 2023)*

Toxic areas are to be considered separately from the hazardous area classification. See Subsection 12/5 and 12/6 for additional details on the hazardous and toxic areas, respectively.

5 Hazardous Area Zones *(1 September 2023)*

Hazardous area zones 0, 1 and 2 as indicated in 5C-13-12/5.1, 5.2 (except item .7) and 5.3 of the *Marine Vessel Rules* are applicable.

6 Toxic Areas

6.1 *(1 September 2023)*

In addition to the hazardous area considerations for the selection of electrical equipment identified above, which is focused on mitigating the fire and explosion risk in enclosed spaces, due consideration is to be given to the toxicity risk from potential leak sources, venting from fuel systems and pressure relief systems or ventilation from spaces containing potential sources of ammonia release/leakage.

6.2 *(1 September 2023)*

The criteria throughout this document supports limiting venting only for safety reasons and providing distance limits on key features to mitigate the toxicity risks where fuel releases and leakages may occur. Where alternatives, or reductions in these safety distances are proposed, gas dispersion analyses, or equivalent, to safely address an ammonia leakage or release, are be submitted to validate the arrangements.

6.3

The ventilation outlets from hazardous enclosed spaces may be grouped together in the same location on open deck to limit the hazardous areas. In such cases arrangements are to prevent backflow into adjacent systems.

6.4 *(1 September 2023)*

To reduce the risks from potential toxic releases (generally from PRVs, hazardous space ventilation exits, bunker stations and other potential release sources protected by drip trays), the following areas are to be considered as toxic areas and are required to be located at the following minimum distances from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-toxic and non-hazardous areas:

i) B or 25 m, whichever is less, from the vent mast

ii) 10 m from

- ***a)*** Entrances to the spaces containing potential source of ammonia release,
- ***b)*** Ventilation outlets from secondary enclosures around ammonia piping and from the spaces containing potential source of ammonia release,
- ***c)*** Bunker manifold valves and all other flange connections of ammonia fuel piping as well as from the spillage coamings surrounding it,
- ***d)*** Engine exhaust exits, crankcase and sump tank vent outlets, as applicable,

iii) 5 m from the vent outlets of ammonia drain tank(s) and auxiliary circuits of engines.

Commentary:

For vessels less than 90 m in length, smaller distances may be permitted, based on justification through gas dispersion analysis.

End of Commentary

6.5 *(1 September 2023)*

Vent mast is to be arranged at least B/3 or 6 m, whichever is greater, above the open deck and 6 m from working areas and gangways. In addition, all other vent and ventilation pipes listed in 12/6.4 are to be arranged at least 4 m above the open decks, working areas, walkways and/or gangways.

6.6 *(1 September 2023)*

Air intakes and outlets of the spaces containing potential source of ammonia release/leakage are to be so arranged as to minimize the possibility of recycling of hazardous and toxic vapors through the ventilation system.

6.7 *(1 September 2023)*

Fuel preparation room and tank connection space access on open deck within a toxic zone, as defined in 12/6.4, may be considered subject to further evaluation and approval during the risk assessment required by 4/2.3.

Commentary:

Emergency Escape Breathing Devices (EEBDs) are to be considered for the spaces protected by airlocks.

End of commentary

6.8 *(1 September 2023)*

Openings and ventilation outlets of the spaces normally unmanned (i.e. bosun stores, deck stores, workshops, etc.) may be allowed to be located within toxic areas provided that the space is fitted with an independent mechanical extraction ventilation system, providing a minimum of 8 air changes per hour. Ventilation inlets of such spaces are to be from a safe area. In addition, the ventilation system is to be activated before any personal enter to such spaces.

6.9 *(1 September 2023)*

Potentially toxic areas are to be specially considered by the risk assessment in 4/2.3 and a gas dispersion analysis may be required to validate the arrangements.

LSA equipment, muster stations and escape routes are not to be located in such areas.

Operational and emergency response procedures are to consider and to provide guidance for the safe operation and escape of crew from such areas.

SECTION 13
Ventilation

1 Goal

The goal of this Section is to provide for the ventilation required for operation of gas-fueled machinery and equipment.

2 Functional Requirements *(1 September 2023)*

The functional requirements detailed in Subsection 3/2 of this document are applicable.

3 General

3.1

Ventilation design and arrangements are to be in accordance with 5C-13-13/3 of the *Marine Vessel Rules*.

3.2 *(1 September 2023)*

The ventilation arrangements are to take into account the density of any potential releases of ammonia.

Commentary:

While gaseous anhydrous ammonia is lighter than air, it is hygroscopic and therefore readily absorbs moisture. Releases in the air may form vapors that are heavier than air. Please see 13/4.2 for the position of the ventilation inlet and outlets in the spaces.

End of Commentary

3.3 *(1 September 2023)*

All air intakes and other openings into the accommodation spaces, service spaces and control stations, which are normally manned, are to be fitted with closing devices operated from within the spaces. As per 15/8.2 vi), these intakes and other openings are required to be fitted with gas detectors and the closing devices are to close automatically upon gas detection in accordance with Section 15, Table 1.

3.4

The windows and side scuttles of accommodation spaces, service spaces and control stations, which are normally manned, and facing ammonia fuel tanks located on deck and/or the vent mast or riser location are to be of the fixed (non-opening) type.

4 Ventilation of Enclosed Spaces Containing Potential Source of Ammonia Release/Leakage *(1 September 2023)*

4.1

To avoid ammonia vapors passing from one space to another, each space is to be provided with separate ventilation systems, except that a combined ventilation system for fuel preparation rooms, tank connection spaces or tank hold spaces, as applicable, may be accepted subject to a special approval during the risk assessment required by 4/2.3 considering any single failure on the combined ventilation system should not adversely affect the ships' essential services as per 4-8-1/7.3.3 of the *Marine Vessel Rules*.

4.2

Air inlet openings are to be positioned as low as practicable in the space being ventilated and exhaust openings are to be both the lowest and highest points (see commentary under 13/3.2) and at opposite sides to the air inlet openings so that ammonia vapor cannot accumulate in the space.

Commentary:

Alternative arrangements other than having both low and high exhaust ventilation outlets may be considered with suitable justification and supporting analysis that is to be submitted to ABS for approval.

End of Commentary

4.3

Each space is to be provided with an effective extraction type mechanical forced ventilation system and maintained at underpressure relative to the surrounding spaces. A ventilation capacity of at least 30 air changes per hour is to be provided. The rate of air changes may be reduced if other adequate means of explosion protection are installed. The equivalence of alternative installations is to be demonstrated by a risk assessment and approval by the Administration.

4.4

Each space is to be continuously ventilated and upon failure an alarm is to be provided at a continuously manned central control station.

4.5

Means are to be provided for stopping the ventilation fans and closing the ventilation openings from a readily accessible position located outside the space.

4.6

The number and power of the ventilation fans for the spaces are to be such that if one fan or a group of fans on the same circuit from the main switchboard or emergency switchboard, are out of service, the capacity of the remaining ventilation fan(s) is not to be less than 100% of the total required.

4.7

Approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the fuel preparation rooms and tank connection spaces, as applicable.

4.8

To facilitate the crews entering or exiting from each space, a push button for temporary stop of ventilation to reduce differential pressure is to be located adjacent to the door(s).

4.9

Each space is to be provided with an increased mechanical type of gas evacuation system to quickly dissipate a catastrophic leak of ammonia to reduce the toxicity, fire and explosion risks. The system is to be designed and constructed in accordance with the following requirements:

4.9.1

The gas evacuation system is to be independent of other shipboard ventilation systems; however, it need not be independent of the ventilation system required by 13/4.3, provided that a single failure on either system could not cause a complete loss to ventilation of the space.

4.9.2

The gas evacuation system is to be arranged to automatically start when the concentration of ammonia in the space exceeds 150 ppm.

4.9.3

The combined capacity of the ventilation and gas evacuation fans is to provide minimum 45 air changes per hour based on the total empty volume of the space.

4.9.4

The gas evacuation system controls are to be positioned outside the space.

5 Machinery Spaces

5.1

The ventilation system for machinery spaces containing consumers (engine room) is to be independent of all other ventilation systems.

5.2

Spaces enclosed in the boundaries of consumer machinery spaces (such as purifier's room, engine-room workshops and stores) are considered an integral part of machinery spaces containing consumers and, therefore, their ventilation system does not need to be independent of the machinery space ventilation system.

6 Bunkering Station

The bunker station ventilation arrangements are to be in accordance with 5C-13-13/7 of the *Marine Vessel Rules*.

7 Ducts and Double Pipes

7.1

The ventilation arrangements for fuel pipe ducting and double wall pipes are to be in accordance with 5C-13-13/8 of the *Marine Vessel Rules*.

The number and power of the ventilation fans for fuel pipe ducting and double wall piping is to be such that if one fan, or a group of fans with common circuit from the main switchboard or emergency switchboard, are out of service the capacity of the remaining ventilation fan(s) is not to be less than 100% of the total required.

7.2 *(1 September 2023)*

The ventilation outlet from the secondary enclosure around the ammonia piping system is to be located in accordance with 12/6.4.

SECTION 14
Electrical Installations

1 Goal

The goal of this Section is to provide for electrical installations that minimize the risk of ignition in the presence of a flammable atmosphere.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this document and 5C-13-14/2 of the *Marine Vessel Rules* are applicable.

3 General

3.1 *(1 September 2023)*

Electrical installations are to be in accordance with 5C-13-14/3 and 4-8-4/27 of the *Marine Vessel Rules*.

3.2 *(1 September 2023)*

For the purposes of application of IEC standards and selection of electrical equipment, ammonia is treated as anhydrous ammonia with IEC LEL and UEL limits of 15% and 28% respectively. Electrical equipment is to meet ISO/IEC 80079-20-1 group IIA class T1.

SECTION **15**

Control, Monitoring and Safety Systems

1 Goal

The goal of this Section is to provide for the arrangement of control, monitoring and safety systems that support an efficient and enhance the safety of operation of the gas-fueled installation as covered in the other Sections of this document.

2 Functional Requirements

2.1 *(1 September 2023)*

The functional requirements detailed in Subsection 3/2 are applicable.

3 General

3.1 *(1 September 2023)*

Suitable instrumentation devices are to be fitted to provide a local and a remote reading of essential parameters to allow safe management of all fuel installations including bunkering.

3.2 *(1 September 2023)*

Sensors activating high level alarms are to be provided for the bilge wells arranged in tank connection spaces, fuel preparation rooms or other enclosed spaces containing potential sources of ammonia release/ leakage. Bilge wells in such spaces are also to be provided with temperature sensors that activate the relevant safety systems in accordance with Table 1.

3.3 *(1 September 2023)*

Liquid ammonia detection systems are to be installed for the fuel tank hold spaces or interbarrier spaces.

Commentary:

The requirement for leakage detection may be waived for the hold spaces surrounding Type C fuel tanks.

End of Commentary

3.4

Machinery spaces containing ammonia are to be fitted with remote monitoring in accordance with the **ACC**, **ACCU** or **ABCU** requirements of Section 4-9-1 of the *Marine Vessel Rules*.

4 Bunkering and Liquefied Fuel Tank Monitoring

4.1

Each fuel tank is to be provided with means for indicating fuel level, pressure and temperature.

4.2

The fuel tank level and overflow control monitoring arrangements are to be in accordance with 5C-13-15/4 of the *Marine Vessel Rules*.

4.3

In addition to the indirect and closed level indicator types detailed by 5C-13-15/4.1.3 of the *Marine Vessel Rules*, the fuel tank liquid level gauges may be of the following closed types:

Closed devices which penetrate the fuel tank, but which form part of a closed system and keep the fuel from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If the closed gauging device is not mounted directly onto the tank, it is to be provided with a shutoff valve located as close as possible to the tank.

4.4 *(1 September 2023)*

Arrangements are to be made for submerged fuel-pump motors to automatically shut-down in the event of low-low liquid level in the fuel tank. The automatic shut-down may also be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shut-down is to give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety center.

5 Bunkering Control

Bunkering control arrangements are to be in accordance with 5C-13-15/5 of the *Marine Vessel Rules*.

6 Compressor and Pump Monitoring *(1 September 2023)*

6.1

Compressor monitoring arrangements are to be in accordance with 5C-13-15/6 of the *Marine Vessel Rules*.

6.2 *(1 September 2023)*

Means to monitor the pressure at each ammonia fuel pump discharge are to be provided locally and remotely.

7 Engine Monitoring *(1 September 2023)*

Engine monitoring arrangements are to be in accordance with 5C-13-15/7 of the *Marine Vessel Rules*.

Commentary:

As the ammonia fueled engines are currently under development stage, control and monitoring requirements will be matured based on the results of engine safety concept, FMEA and HAZOP studies.

End of commentary

8 Gas Detection Systems

8.1 *(1 September 2023)*

Gas detection arrangements are to be in accordance with 5C-13-15/8 of the *Marine Vessel Rules*, as applicable.

8.2 *(1 September 2023)*

In addition to the (ammonia) gas detection locations referenced by 5C-13-15/8.1 of the *Marine Vessel Rules*, ammonia vapor detection and alarm system is to be provided to warn of the release of ammonia at the following locations, as applicable:

i) Bunker stations

ii) Vent mast as identified under 6/6.3

iii) Internal combustion engine exhaust system exits from aftertreatment system (to be confirmed based on the engine safety concept and/or risk assessment)

iv) Internal combustion engine crankcase breather, or under piston space, vent exits (may be applicable only to trunk piston type engines) (to be confirmed based on the engine safety concept and/or risk assessment)

v) Engine auxiliary piping systems where gas may leak directly into the system medium

vi) All air intakes and other openings into the accommodation spaces, service spaces and control stations, which are normally manned – see 13/3.3.

8.3 *(1 September 2023)*

Fuel tank hold or interbarrier spaces are to be provided with detectors capable of measuring gas concentrations from 0% to 100% by volume will activate an alarm before the gas concentration in the space reaches 30% of the lower explosion limit (LEL) in air.

Commentary:

The requirement for LEL detection may be waived for the hold spaces surrounding Type C fuel tanks.

End of Commentary

8.4 *(1 September 2023)*

Where the ammonia gas detector range of operation cannot cover the ppm levels required for toxicity detection and the percentage (%) level required for fire and explosion detection, separate gas detectors covering each range of operation are required at each detector location.

8.5 *(1 September 2023)*

Gas detection equipment is to be designed, installed and tested in accordance with recognized standards for toxicity and is to be suitable for ammonia service.

9 Fire Detection

The required safety actions upon detection of a fire are given under Subsection 15/12.

10 Ventilation

10.1 *(1 September 2023)*

Any loss of the required ventilating capacity is to give an audible and visual alarm on the navigation bridge, or in a continuously manned central control station or safety center, and with the required safety actions in accordance with Subsection 15/1 & Table 1.

Commentary:

Acceptable means to confirm the ventilation system in operation has the *"required ventilating capacity"* may be one of the following:

- Monitoring of the ventilation electric motor or fan operation combined with underpressure indication; or
- Monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication; or
- Monitoring of ventilation flow rate to indicate that the required air flow rate is established.

End of Commentary

10.2 *(1 September 2023)*

Loss of ventilation in the fuel preparation room and tank connection space is to automatically shut-down the pumps and compressors, and other available equipment located in the spaces.

10.3 *(1 September 2023)*

Ventilated secondary enclosures around fuel piping are to be fitted with flow sensor(s) to monitor and alarm in case of any failure in the ventilation system.

11 Safety Functions of Fuel Supply Systems

11.1

The fuel supply safety functions are to be in accordance with 5C-13-15/11 of the *Marine Vessel Rules*.

11.2 *(1 September 2023)*

Means of manual emergency shutdown of fuel supply to the consumers or set of consumers is to be provided on the primary and secondary escape routes from the consumer compartment, at a location outside consumer space, outside the fuel preparation space and at the bridge. The activation device is to be arranged as a physical button, conspicuously marked and protected against inadvertent operation and operable under emergency lighting.

11.3 *(1 September 2023)*

The heating medium circuit for the fuel as well as the heated fuel in the supply lines to consumers are to be provided with temperature monitoring at the heat exchanger outlet. The heat exchanger outlet of the heating medium circuit is to have a low temperature alarm.

12 Monitoring and Safety Functions *(1 September 2023)*

12.1 *(1 September 2023)*

Monitoring and safety system functions are to be provided in accordance with Tables 4, 6, 8 and 9 of 5C-13-15 of the *Marine Vessel Rules*, as applicable, and Table 1 of this document.

Commentary:

The tables referred to above incorporate the IMO International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code) and may be adjusted as necessary for the use of anhydrous ammonia as fuel.

End of Commentary

12.2 *(1 September 2023)*

If the concentration of ammonia exceeds the indicated levels in Table 1, the detectors are to activate audible and visual alarms locally, at the navigation bridge and at the continouously manned central control station.

12.3 *(1 September 2023)*

The number of detectors in each space is to be considered taking into account the size, layout and ventilation of the space. As far as practicable and unless otherwise justified, at least three(3) detectors are to be installed in each space listed under 15/8.1 and 8.2.

The detectors are to be located where gas may accumulate and preferably in ventilation outlets considering also that the ammonia vapor can initially be heavier than air. Gas dispersal analysis or other alternative options may be used to find the best arrangement.

12.4

Voting principle for the detectors may be used to reduce the number of unwanted alarms/safety actions, but should not reduce the ability of the system to respond to a real incident. An example of a voting principle table is given in the Table below:

Table for Voting Principle

Type[6]	*Minimum Number of Detectors for Alarm/Action*[6]	*Minimum Number of Detectors per Area*[4]	*Voting Nomenclature*[6]
Lower Level Gas	2	3	2 out of N (N≥3)
Lower Level Gas w/ Faulty Detector	1	2	1 out of N (N≥2)
Higher Level Gas	1	2	1 out of N (N≥2)
	or		
	2	3	2 out of N (N≥3)

Note:

1. Minimum number of detectors required for alarm/action out of 'N' number of detectors in a zone/area.

2. In principle, lower level will activate the alarm and higher level will initiate the relevant safety action (see Table 1).

3. Faulty detectors vote as alarmed.

4. In a group of 3 or more detectors, the activation of one lower level gas (1x LLG) and one higher level gas (1x HLG) detector is to be considered as equivalent to a confirmed high-level gas alarm, as per the above table.

Commentary:

Alternate voting scheme will be considered acceptable if it provides equivalent level of safety per the intent of these requirements. Voting principles apply per group of detectors.

End of Commentary

12.5 *(1 September 2023)*

If the concentration of ammonia exceeds 150 ppm as confirmed by the gas detection system (see 15/12.3 and 15/12.4) in fuel preparation room or in tank connection space, the detector(s) are to:

i) Activate the water screen systems required by 5/9.2

ii) Activate the increased ventilation system required by 13/4.9 and

iii) Initiate a shutdown of the ammonia fuel supply system by closure of the tank valves and/or the fuel supply valves with automatic purging of the lines as required by 9/5.5, 9/5.7 and 9/5.12.

12.6 *(1 September 2023)*

If the concentration of ammonia exceeds 300 ppm as confirmed by the gas detection system (see 15/12.3 and 15/12.4) within the secondary enclosure of the fuel piping, the detector(s) is to initiate a shutdown of the ammonia fuel supply system by closure of the fuel supply valves and automatic purging of the system as required in 9/5.12. Tank valve or fuel preparations room valves may also be closed with the gas detection in case there are secondary enclosure arrangements for the fuel piping upstream of the master fuel valve.

12.7 *(1 September 2023)*

If the concentration of ammonia exceeds 300 ppm as confirmed by the gas detection system (see 15/12.3 & 15/12.4) in the enclosed or semi-enclosed bunkering station, the detector(s) is to initiate a shutdown of the bunkering system ESD valves. The water spray system in the area as detailed in 11/5.3 is also to be manually activated as an additional safety measure.

TABLE 1
Monitoring and Safety Functions *(1 September 2023)*

Parameter	*Alarm*	*Automatic shutdown of fuel supply valves*[(1)]	*Automatic shutdown of tank valves*	*Automatic shutdown of the bunker manifold ESD valves*[(2)]	*Activation of other safety systems (A): Automatic (M): Manual*
GAS DETECTION[(4)(6)]					
Gas detection in tank hold space/interbarrier space at 25 ppm and 30% of the LEL	X				
Gas detection in fuel preparation room at 25 ppm	X				
Gas detection in fuel preparation room at 150 ppm	X		X[(7)]		Stop all equipment in the space (M) Activation of increased ventilation (A) Activation of water screen system (M)
Gas detection in tank connection space at 25 ppm	X				

Parameter	*Alarm*	*Automatic shutdown of fuel supply valves*[1]	*Automatic shutdown of tank valves*	*Automatic shutdown of the bunker manifold ESD valves*[2]	*Activation of other safety systems (A): Automatic (M): Manual*
Gas detection in tank connection at 150 ppm	X		X		Stop all equipment in the space (M) Activation of increased ventilation (A) Activation of water screen system (M)
Gas detection in machinery space containing consumers at 25 ppm	X				
Gas detection in machinery space containing consumers at 50 ppm	X	X			
Gas detection in secondary enclosure of fuel pipes at 150 ppm	X				
Gas detection in secondary enclosure of fuel pipes at 300 ppm	X	X			Purge the fuel system through the fuel treatment and vent control system (A)
Gas detection at vent mast exit at 300 ppm	X				
Gas detection at ventilation inlets and openings to accommodation spaces, service spaces and control stations at 25 ppm	X				Closing of all closing devices at ventilation inlets and openings (A)
Gas detection at bunker stations at 150 ppm	X				
Gas detection at bunker stations at 300 ppm	X			X	Activation of the water spray system (M)
Gas detection to engine auxiliary system (cooling, lube oil, etc.)	X[3]				
FIRE DETECTION					
Fire detection in fuel storage hold space	X				

Parameter	*Alarm*	*Automatic shutdown of fuel supply valves*[1]	*Automatic shutdown of tank valves*	*Automatic shutdown of the bunker manifold ESD valves*[2]	*Activation of other safety systems (A): Automatic (M): Manual*
Fire detection in machinery space containing ammonia fueled engines	X				
Fire detection in tank connection space or fuel preparation room including ventilation trunks of those spaces	X		X	X	Stop ventilation system (M) Close fire dampers (A)
LOSS OF VENTILATION					
Loss of ventilation in fuel preparation room	X		X[7]		Stop all equipment in the space (A)
Loss of ventilation in tank connection space	X		X		Stop all equipment in the space (A)
Reduced ventilation in fuel preparation room or tank connection space	X				
Loss or reduced ventilation within the secondary enclosure of fuel piping	X	X			
Loss of ventilation in enclosed or semi-enclosed bunker station	X			X	
Loss of ventilation in airlocks	X				
LEAKAGE (LIQUID) DETECTION & LEVEL ALARM					
Leakage detection in fuel tank hold space/interbarrier space	X				
High level alarm in fuel tank(s)	X			X[8]	
Low level alarm in fuel tank(s)	X				
Low-low level alarm in fuel tank(s)	X				Stop the fuel pumps[5](A)
High level alarm at bilge wells in tank connection space	X				
High level alarm at bilge wells in fuel preparation room	X				

Parameter	*Alarm*	*Automatic shutdown of fuel supply valves*[1]	*Automatic shutdown of tank valves*	*Automatic shutdown of the bunker manifold ESD valves*[2]	*Activation of other safety systems (A): Automatic (M): Manual*
TEMPERATURE ALARM					
Low temperature alarm at bilge well in tank connection space or fuel preparation room	X		X[7]		
Low temperature alarm at fuel heat exchanger outlet (heating medium circuit)	X				
High temperature alarm on fuel tank(s)	X				
PRESSURE ALARM					
Inert gas low pressure within the secondary enclosure of fuel piping	X				
Abnormal pressure in fuel suppy lines	X				
Low (where vacuum protection is required) or high pressure in fuel tank(s)	X			X	Close ESD bunker manifold valves if the alarm during bunkering operation (A)
OTHERS					
Failure of actuating system of the fuel supply system control valves	X	X[9]			
Loss of bunkering ESD valve motive power	X			X	
Manual bunker ESD shutdowns or ESD signal from bunker supplier	X			X	
Automatic shutdown of engine (engine failure)	X	X[9]			
Manual activated emergency shutdown of engine	X	X			

Notes:

1) After closure of the master fuel valve(s), double block and bleed valves as well as the automatic valves in the fuel preparation room are to close.

2) ESD signal and automatic activation of the ESD valves on the bunker receiving ship to activate automatic shutdown of the ESD valves and supply pumps at the bunker supplier.

3) At the locations indicated by 9/5.16.

4) Refer to Section 15 of this document for the number of gas detectors, logic and voting principle.

5) Applies to submerged electric fuel pumps.

6) Additional gas detectors may be required by the engine safety concept specific to the engine type (e.g. crankcase breather or under piston space vent, exhaust outlets, etc.).

7) Tank valve(s) or fuel preparation room valves are to close, based on the application and arrangement of the vessel.

8) Sensor that automatically activates the shut-off valve is to operate independently of the high liquid level alarm on the fuel tank.

9) Only double block and bleed valves to be activated.

10) Other alternative monitoring and safety actions as well as ppm limits can be proposed with justification subject to consideration during the risk assessment and final approval by ABS.

11) Additional features for monitoring and safety actions may be required by gas dispersion analysis and the detailed risk assessment required by 4/2.3.

SECTION 16

Survey, Manufacture, Workmanship and Testing

1 General

1.1

Materials in general are to comply with the requirements of the ABS *Rules for Materials and Welding (Part 2)*.

1.2

Materials for fuel containment, fuel piping, process pressure vessels are to be in accordance with Subsection 7/4 of this document.

1.3

The manufacture, testing,inspection and documentation is to be in accordance with Section 5C-13-16 of the *Marine Vessel Rules* and the ABS *Rules for Survey After Construction (Part 7)*.

1.4 Survey During Construction

For survey during construction of various equipment and systems, the survey is to include applicable sections of Chapter 5C-13, 4-1-1/Tables 1-5 and Chapter 5C-8 of the *Marine Vessel Rules*.

1.5 Survey After Construction

1.5.1 Annual Survey *(1 September 2023)*

Annual survey is to include applicable sections of 7-6-2/1.7.3 and 7-6-2/1.9 of the ABS *Rules for Survey After Construction (Part 7)*.

1.5.2 Intermediate Surveys

Intermediate survey is to include applicable sections of 7-3-2/3.1.8 of the ABS *Rules for Survey After Construction (Part 7)*.

1.5.3 Special Periodical Surveys

Special survey is to include applicable sections of 7-6-2/3.7 of the ABS *Rules*. *for Survey After Construction (Part 7).*

Commentary:

Operational procedures, training or national requirements, shown in *Arial Italic*, are not required for classification and shown for information only.

End of Commentary

1 General

1.1

Drills and emergency exercises are to be conducted on board at regular intervals in accordance with Section 5C-13-17 of the *Marine Vessel Rules*.

Commentary:

Operational procedures, training or national requirements, shown in *Arial Italic*, are not required for classification and shown for information only.

End of Commentary

1 General

1.1

Operation and maintenance procedures are to be in accordance with Section 5C-13-18 of the *Marine Vessel Rules*.

1.2

The operational procedures are to include the limitations for machinery space entry detailed under 5/11.7.