Guide for

Ammonia Fueled Vessels

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GUIDE FOR

AMMONIA FUELED VESSELS

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Foreword

Due to increased 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 the zero-carbon fuel properties and ability to produce ammonia from renewable and sustainable sources. This Guide 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).

The application of this Guide is for vessels covered by the IGF Code as addressed by 5C-13 of the *Marine Vessel Rules*. ABS will consider application of this Guide 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 Guide.

This Guide 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 of this Guide 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.

GUIDE FOR

AMMONIA FUELED VESSELS

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SECTION 1
Introduction

1 Scope

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 particular 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. At present, no such IMO instruments exist for the use of anhydrous ammonia as fuel.

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

2 Objective

The objective of this Guide is to provide Classification criteria for the arrangements, construction, installation and survey of machinery, equipment and systems for vessels operating with ammonia as fuel in order 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 Guide. 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 of this Guide).

Commentary:

Conventional fuel flashpoint testing refers to closed cup testing of fuel oils and hence is not an applicable test for gases. For the purposes of this guide, the **LFFS** notation is applied to IGF Code vessels on the basis that the process of the IMO Alternative Design process is applicable.

Commentary:

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

End of Commentary

3.2 Dual Fuel Diesel Engine Power Plant

Where a dual fuel diesel engine power plant is installed, the **DFD** notation is required and the unit is to be designed, constructed and tested in accordance with this Guide and the *Marine Vessel Rules*.

3.3 Reliquefaction System

Where a Reliquefaction or Refrigeration System is installed, the **RELIQ** notation is required and the unit is to be designed, constructed and tested in accordance with this Guide and the *Marine Vessel Rules*.

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

Where the conditions of the Guide are proposed to be used to comply, 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.

Commentary:

Refer to 5C-13-2/3 of the *Marine Vessel Rules* for the IGF Code Alternative Design criteria.

End of Commentary

6 Format

This Guide 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 5C-13 of the *Marine Vessel Rules* and is required for classification.

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

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

Where this Guide 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 Guide.

The text contained in this Guide that comes directly from the IGF Code is presented in italics “Times New Roman” typeface.

SECTION 2
General

1 Application

This Guide 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 Guide has been developed for application to ships covered by the IGF Code. ABS will consider application of this Guide 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, demonstrate the same level of safety as natural gas and with agreement of the flag Administration.

End of Commentary

2 Definitions

For the purpose of this Guide, 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) "*Engine room*" is a machinery space containing ammonia fueled engine(s).

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

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

iv) "*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.

v) "*GVU*" means Gas Valve Unit and refers to the consumer gas regulating valve train and which may include the double block and bleed functionality. May also be known as "GVT – Gas Valve Train" or FVT – Fuel Valve Train" and is typically located in a dedicated space, enclosure or the fuel preparation room.

vi) "*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*.

vii) "*Portable tank*" means an independent tank being able to be:

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

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

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

ix) "*Tank Connection Space*" means a space surrounding all tank connections and tank valves.

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

3 Alternative Design

Equipment, components, and systems for which there are specific requirements in this Guide, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this Guide. 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 Guide 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 Guide 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 for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be equivalent to that outlined in this Guide. 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

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

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

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) Vent mast and venting arrangements

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

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

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

4.2 Fuel Containment System

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

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 of this Guide, plans and specifications covering the fuel bunkering system listed below are to be submitted, and are, as applicable, to include:

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 of this Guide, 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 of this Guide, 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 Section 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-fuelled 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.

The fuel supply, storage and bunkering systems, together with the consumers, are to be designed to prevent venting under all normal operating conditions including idle periods. Venting is only permitted for safety reasons (emergencies).

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.

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

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

Commentary:

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. Systems and equipment are to be designed to prevent releases during normal operation, maintenance, and inspection and/or to treat such releases to acceptable levels – see 6/6.2, 6/6.3, 8/2.2, 9/2.2, 9/5.1, 9/5.2, 10/3.2 and 10/3.3 of this Guide. Anhydrous ammonia is extremely harmful to aquatic life, so relief or direct discharge to seawater is to be avoided.

End of Commentary

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 physical 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

The risks are to be analyzed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion, toxicity 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 be documented by 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

The risk assessment is to specifically consider, but not limited to, the items referenced by this Guide and 5C-13 of the *Marine Vessel Rules*:

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

ii) Duration of the EEBDs – see 5/11.7 of this Guide

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

iv) The toxic areas identified by 12/6 of this Guide, 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 GVU or GVT spaces/enclosures – see 9/5.8 of this Guide

vi) Capacity of drip trays – see 5C-13-5/10.5 of the of the *Marine Vessel Rules*

vii) Arrangements of airlocks – see 5C-13-5/12.3 of the *Marine Vessel Rules*

viii) Evaluation of the fuel containment system – see 5C-13-6/4.1.1 of the *Marine Vessel Rules*

ix) Arrangements of closed or semi-enclosed bunker stations – see 5C-13-8/3.1.1 and 5C-13-13/7 of the *Marine Vessel Rules*

x) 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 Guide and 5C-13-15/8.1.10 of the *Marine Vessel Rules*

xi) 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 and 12/6.4 of this Guide

2.4

The risk assessment plan developed and submitted to ABS for review should contain:

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 *Guide for Risk Evaluations for the Classification of Marine-Related Facilities*.

3 Limitation of Explosion Consequences

3.1

To limit the consequences of an explosion in any space containing any potential source of release[1] of flammable vapor/liquid and potential ignition sources, 5C-13-4/3 of the *Marine Vessel Rules* is applicable.

Note:

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

SECTION 5

Ship Design and Arrangement

1 Goal

The goal of this Section is to provide for 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 Guide 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 5C-13 references from this Guide, 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

5.1

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*.

6 Fuel Preparation Room

6.1 General

6.1.1

Equipment and systems for ammonia fuel supply, and as applicable, equipment for compression, reliquefaction or cooling of ammonia in the fuel tanks, is to be located in a dedicated fuel preparation room/space.

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

Drip trays and spray shields, or equivalent means, are to be fitted where leakage may occur from the potential sources of release. As applicable, arrangements are to consider unacceptable cooling in case of cryogenic or compressed gas leakages, and in consideration of the probable maximum leakage scenario.

6.1.2

Fuel preparation rooms are to be separated by gastight bulkheads and decks from other spaces.

6.1.3

Fuel preparation rooms are to be located outside other machinery spaces of category A.

6.1.4

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.

6.1.5

Fuel preparation rooms are to contain only the equipment essential for fuel conditioning, preparation and supply, together with necessary safety equipment such as fire and gas detection, low oxygen level detection system, fi-fi equipment, bilge equipment, etc.

6.1.6

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, pressure/vacuum relief venting to a safe location (mast) can be provided.

6.1.7

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

6.2 Access, Openings and Water Screens

6.2.1

Unless permitted by SOLAS Chapter II-2 Regulation 13.2, a minimum of two widely separated means of escape are to be provided for these spaces. Water screens are to be provided above

access doors and operable manually from outside the compartment and automatically in accordance with Section 15 of this Guide.

One of the means of escape may be a vertical ladder through a hatch to the weather. In that 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.

6.2.2

Duct, pipe and cable penetrations of bulkheads and decks of the fuel preparation room are to be made gastight.

7 Bilge Systems

7.1

Bilge system design and arrangements are to be in accordance with 5C-13-5/9 of the *Marine Vessel Rules*.

7.2 Drainage of Fuel Preparation Room

7.2.1

The fuel preparation room is to be provided with an independent bilge system.

7.2.2

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

7.2.3

The draining and pumping arrangements are to be such as to prevent the build-up on free surfaces. The draining system is to be sized to remove not less than 125% of the capacity of the water screen system.

7.2.4

Discharges from fuel preparation bilge systems are to be led to independent holding tanks or drain tanks, or arranged for further processing to safe levels, and disposal ashore. These tanks are to be in accordance with 5C-9-15/12.3 of the *Marine Vessel Rules*.

Commentary:

Anhydrous ammonia is extremely harmful to aquatic life, so relief or direct discharge to seawater is to be avoided.

End of Commentary

8 Drip Trays

8.1

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

9 Arrangement of Entrances and Other Openings in Enclosed Spaces

9.1

Arrangements of entrances and other opening 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*.

10 Airlocks

10.1

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

11 Personnel Safety and PPE

11.1

Suitable gas tight protective equipment including eye protection to a recognized national or international standard is to be provided for protection of crew members engaged in normal bunkering or fuel system maintenance and operation.

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 Subsection 4/2 of this Guide 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

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 to a recognized standard.

iii) steel-cored rescue line with belt.

iv) explosion-proof lamp.

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 of this Guide,

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 of this Guide.

11.7

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 Subsection 4/2 of this Guide 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 Subsection 4/2 of this Guide 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 and emergency escape plan.

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 Guide and 5C-13-6/2 of the *Marine Vessel Rules* are applicable.

3 General

3.1

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.

5 Portable Tanks

5.1

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

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.

However, fuel tank PRV (Pressure Relief Valve) vent exits are be arranged at a distance at least equal to B or 25 m, whichever is less, from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous areas. For vessels less than 90 m in length, smaller distances may be permitted, based on justification through gas dispersion analysis.

In all cases, the 25 m distance to life saving appliances equipment, muster stations and escape routes is to be maintained unless justified by a gas dispersion analysis.

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 of this Guide.

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 of this Guide.

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

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 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*.

9 Atmospheric Control Within the Fuel Containment

9.1

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*.

12 Reliquefaction and Refrigeration Systems

12.1

The dedicated fuel reliquefaction and refrigeration systems are to be designed in accordance with 5C-13-1/1.3, 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 Guide and 5C-13-7/2 of the *Marine Vessel Rules* are applicable.

3 General Pipe Design

3.1

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

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 Guide.

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 Guide 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 of this Guide for ammonia bunkering PPE requirements.

4 Bunkering Station

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

5 Bunkering Manifold

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

The bunkering manifold valve is to be at least 10 m away from the non-hazardous area openings and air intakes.

6 Bunkering System

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

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 of this Guide.

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

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 Guide 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

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 cryogenic 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 of this Guide.

3.2

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

4 Redundancy of Fuel Supply

4.1

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.

4.2

The propulsion and auxiliary arrangements and fuel supply systems are to be arranged so that in the case of emergency shutdown of the fuel supply the propulsion and maneuvering capability, together with power

for essential services, can be maintained. Under such a condition, the remaining power is to be sufficient to provide for a speed of at least 7 knots or half of the design speed, whichever is the lesser.

Dual fuel engine installations are considered to meet this redundancy objective by their inherent provision of independent conventional fuel oil and ammonia fuel systems.

5 Safety Functions of the Fuel Supply System

5.1

All fuel piping arrangements are to allow for purging and inerting. Fuel systems are to be designed to prevent venting, except where necessary for safety reasons, so that fuel from fuel system blowdowns, fuel changeovers, venting, etc. are lead to a fuel return or fuel storage/treatment system.

Discharges from fuel supply systems are to be led to the vent mast or riser location.

5.2

Where the fuel treatment or vent control systems 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.

5.3

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 of this Guide is activated.

Commentary:

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

End of Commentary

5.4

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.

5.5

The main fuel supply line 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 of this Guide.

5.6

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 9/5.3 of this Guide.

5.7

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.

5.8

Each consumer is to be provided with a "double block and bleed" valve arrangement. These valves are to be arranged as outlined in *i)* or *ii)* below, so that when the safety system required in Section 15 of this Guide 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 Gas Valve Unit (GVU) or Gas Valve Train (GVT), 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 Subsection 4/2 of this Guide.

5.9

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

5.10

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.

5.11

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.

5.12

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 9/5.5 of this Guide. 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 9/5.6 of this Guide.

End of Commentary

5.13

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.

5.14

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 riser location.

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*.

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

7.1

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

8.1

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

9.1

Compressors and pumps are to be in accordance with 5C-13-9/9 and 5C-13-9/11 of the *Marine Vessel Rules*.

10 Vaporizers, Heat Exchangers and Pressure Vessels

10.1

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

11.1

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 Guide and 5C-13-10/2 of the *Marine Vessel Rules* are applicable.

2.2

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

3 General

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

All fuel piping is to be arranged for purging and inerting. Fuel systems are to be designed to prevent venting, except where necessary for safety reasons, thus fuel from fuel system blowdowns, fuel changeovers, venting, etc. are to be led to a fuel return or fuel storage/treatment system.

Discharges from fuel supply systems are to be led to the vent mast or riser location.

3.3

Where the fuel treatment or vent control systems 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.

3.4

Internal combustion engines, and as applicable, associated exhaust aftertreatment systems, are to be designed such that ammonia (NH_3) content in the exhaust gas does not exceed 10 ppm.

Where selective catalytic reduction (SCR) exhaust aftertreatment equipment is installed to meet NOx emissions limits, or the above NH_3 limit, with or without dedicated NH_3 control catalysts, the arrangements are to be in accordance with the ABS *Guide for Exhaust Emission Abatement*.

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

3.5

The crankcase breather, or under piston space, gases from those internal combustion engines likely to contain NH_3, as determined by the engine safety concept, are to be designed to achieve a maximum of 10 ppm NH_3 at the vent exit.

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

3.6

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*.

3.7

As applicable, where the engine auxiliary systems 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 riser location.

3.8

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.

3.9

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

3.10

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

Dual fuel internal combustion engine type testing is to include verification of the exhaust and crankcase breather, or under piston space, limits of 10/3.2 and 10/3.3 of this Guide.

5 Fuel Cells

5.1

Fuel cells are to be arranged in accordance with the ABS *Guide 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

2.1

The functional requirements detailed in Subsection 3/2 of this Guide 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.

4 Fire Main

4.1

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

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 fuel piping including bunkering, supply and vent lines located on deck, except where double-walled.

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 Guide. 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.

6 Bunker Station Fire-Extinguishing System

6.1

The bunker station fire-extinguishing system is to be arranged in accordance with 5C-13-11/6 of the *Marine Vessel Rules*.

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*.

8 Fire Extinguishing of Engine Room and Fuel Preparation Room

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 fires.

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 Guide 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.

3 General

3.1

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

3.2

All hazardous and toxic areas should be inaccessible to passengers and unauthorized crew at all times.

4 Area Classification

4.1

The hazardous area classification requirements of 5C-13-12/4 and 4-8-4/27 of the *Marine Vessel Rules* are applicable.

5 Hazardous Area Zones

5.1 Hazardous Area Zone 0

This zone includes but is not limited to the interiors of fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing fuel.

5.2 Hazardous Area Zone 1

This zone includes, but is not limited to:

i) tank connection spaces, and fuel storage hold spaces [(1)] and interbarrier spaces

Note:

(1)

Fuel storage hold spaces for type C tanks are normally not considered as Zone 1.

For the purposes of hazardous area classification, fuel storage hold spaces containing Type C tanks with all potential leakage sources in a tank connection space and having no access to any hazardous area, are to be considered non-hazardous.

Where the fuel storage hold spaces include potential leak sources, e.g. tank connections, they are to be considered hazardous area Zone 1.

Where the fuel storage hold spaces include bolted access to the tank connection space, they are to be considered hazardous area Zone 2.

ii) fuel preparation rooms

iii) areas on open deck or semi-enclosed spaces on open deck above and in the vicinity of any gas outlet intended for the passage of large volumes of gas or vapor mixture, within a vertical cylinder of unlimited height and 6 m radius centered upon the center of the outlet and within a hemisphere of 6 m radius below the outlet

iv) enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, -enclosed bunkering stations, gas valve unit (GVU) / gas valve train (GVT) spaces

v) a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1

vi) other enclosed spaces where leakage of ammonia may occur

5.3 Hazardous Area Zone 2

This zone includes, but is not limited to:

i) areas 4 m beyond the cylinder and 4 m beyond the sphere defined in 12/5.2.(iii) of this Guide

ii) areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1

iii) space containing bolted hatch to tank connection space

iv) airlocks

6 Toxic Areas

6.1

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.

6.2

The criteria throughout this Guide supports limiting venting only for safety reasons and providing distance limits on key features to mitigate the toxicity risks where fuel releases may occur. Where alternatives, or reductions in these safety distances are proposed, gas dispersion analyses, or equivalent, is to 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

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-hazardous areas:

i) 25 m from the vent mast

ii) 10 m from

a) areas on open deck, or semi-enclosed spaces on deck, any fuel tank outlet, gas or vapor outlet, [(2)] bunker manifold valve, other fuel valve, fuel pipe flange, crankcase vent outlet from engines operating according to the Otto cycle, ventilation outlets from Hazardous Zone 1 spaces and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapor mixtures caused by thermal variation;

Note:

(2)

Such areas are, for example, all areas of fuel tank hatches, ullage openings or sounding pipes for fuel tanks located on open deck and gas vapor outlets.

b) areas on the open deck within spillage coamings surrounding bunker manifold valves;

c) areas on open deck or semi-enclosed spaces on deck, fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into Hazardous Zone 1 spaces.

Such potentially toxic areas are to be specially considered by the risk assessment required by Subsection 4/2 of this Guide. 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 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

2.1

The functional requirements detailed in Subsection 3/2 of this Guide and 5C-13-13/2 of the *Marine Vessel Rules* 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

The ventilation arrangements are to take account of 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.

End of Commentary

3.3

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) of this Guide, 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 of this Guide.

3.4

The windows and sidescuttles 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 Tank Connection Space

4.1

The tank connection space arrangements are to be in accordance with 5C-13-13/4 of the *Marine Vessel Rules*.

5 Fuel Preparation Room

5.1 Ventilation of the Fuel Preparation Room

The fuel preparation room is to be efficiently ventilated, and maintained at underpressure relative to surrounding spaces, by means of mechanical exhaust ventilation designed in accordance with the following requirements:

5.1.1

The ventilation system is to be independent of other shipboard ventilation systems.

5.1.2

The number and power of the ventilation fans for fuel preparation rooms are 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.

5.1.3

The ventilation system is to be designed for continuous operation and alarmed at a continuously manned central control station upon failure.

5.1.4

The capacity of the ventilation system is to be of sufficient capacity to provide at least 30 air changes per hour based on the total empty volume of the space.

5.1.5

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

5.1.6

Air inlet openings are to be positioned as low as practicable in the space being ventilated and exhaust openings are to be at highest point and at opposite sides to the air inlet openings so that no ammonia accumulates in the space, with ventilation being circulated from bottom and exhausted at top.

5.1.7

The ventilation exhaust duct outlets are to be positioned at least 10 m (33 ft) from air intake openings, openings to accommodation spaces and other enclosed spaces, and at least 4 m (13 ft) above the open deck.

5.1.8

Ventilation systems for fuel preparation rooms, are to be in operation when fuel supply equipment or fuel management equipment are in operation.

5.1.9

Design of ventilation fans serving the fuel preparation room are also to be in accordance with 4-8-3/11 of *Marine Vessels Rules*.

5.2 Increased Ventilation of the Fuel Preparation Room

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

5.2.1

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 13/5.1 of this Guide.

5.2.2

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

5.2.3

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

5.2.4

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

5.2.5

The exhaust duct outlets are to be positioned at least 10 m (33 ft) from air intake openings, openings to accommodation spaces and other enclosed areas, and at least 4 m (13 ft) above the open deck. In addition, the vent outlets are to be directed upward and arranged so that the discharge of any ammonia vapors is away from accommodations and other enclosed areas, except as otherwise permitted for the normal ventilation outlet.

6 Machinery Spaces

6.1

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

6.2

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.

7 Bunkering Station

7.1

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

8 Ducts and Double Pipes

8.1

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.

8.2

The ventilation outlet from the double wall piping system is to be located in accordance with 13/5.1.7 of this Guide.

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 Guide and 5C-13-14/2 of the *Marine Vessel Rules* are applicable.

3 General

3.1

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

3.2

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. Gas detectors are to be in accordance with Subsection 15/8 of this Guide.

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 Guide.

2 Functional Requirements

2.1

The functional requirements detailed in Subsection 3/2 of this Guide and 5C-13-15/2 of the *Marine Vessel Rules* are applicable.

3 General

3.1

Fuel containment and fuel supply instrumentation arrangements are to be in accordance with 5C-13-15/3 of the *Marine Vessel Rules*.

3.2

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.

5 Bunkering Control

5.1

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

6 Compressor Monitoring

6.1

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

7 Engine Monitoring

7.1

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

8 Gas Detection Systems

8.1

Gas detection arrangements are to be in accordance with 5C-13-15/8 of the *Marine Vessel Rules* suitable for both flammability and toxicity.

8.2

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

i) Fuel storage hold spaces

ii) The vent mast identified under 6/6.3 of this Guide

iii) The ventilation exhaust ducts from fuel preparation and tank connection spaces

iv) Internal combustion engine exhaust system exits for exhaust or end of stack monitoring

v) Internal combustion engine crankcase breather, or under piston space, vent exits;

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

8.3

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.

Monitoring is to be in accordance with Section 15, Table 1 of this Guide.

8.4

Fuel preparation rooms are to be fitted with low oxygen level detection and alarm system.

9 Fire Detection

9.1

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

10 Ventilation

10.1

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 15/12 of this Guide.

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*.

12 Monitoring and Safety Functions

12.1

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

12.2

If the concentration of ammonia exceeds the indicated levels of Section 15, Table of this Guide, the detectors are to activate audible and visual alarms locally and at the manned control station.

12.3

If the concentration of ammonia exceeds 150 ppm in the fuel preparation room, the detectors are to:

i) Activate the water screens required by 5/6.2.1 of this Guide

ii) Activate the increased ventilation system required by 13/5.2 of this Guide and

iii) Initiate a shutdown of the ammonia fuel supply system by closure of the tank valve and the master fuel valve with automatic purge as required by 9/5.4 and 9/5.9 of this Guide.

TABLE 1
Monitoring and Safety Functions

Parameter	*Alarm*	*Automatic activation of water screens, and increased ventilation*	*Automatic shutdown of tank valve*	*Automatic shutdown of the bunker manifold ESD valves*[(1)]	*Automatic shutdown of fuel supply to machinery space containing consumers*
Gas detection in fuel storage hold space at 25 ppm	X				
Gas detection in fuel preparation room at 25 ppm	X				

Parameter	*Alarm*	*Automatic activation of water screens, and increased ventilation*	*Automatic shutdown of tank valve*	*Automatic shutdown of the bunker manifold ESD valves(1)*	*Automatic shutdown of fuel supply to machinery space containing consumers*
Gas detection at fuel preparation room ventilation exits at 25 ppm	X				
Gas detection at tank connection space ventilation exits at 25 ppm	X				
Gas detection in fuel preparation room at 150 ppm	X	X	X		X
Gas detection at fuel preparation room ventilation exits at 150 ppm	X	X	X		X
Gas detection in tank connection space ventilation exits at 150 ppm	X	X	X		X
Low oxygen level detection in fuel preparation room	X				X
Loss of ventilation in fuel preparation room	X		X		X
Gas detection in machinery space containing consumers at 25 ppm	X				
Gas detection in machinery space containing consumers at 50 ppm	X				X(2)
Gas detection in fuel supply pipe ducting or secondary enclosure at 150 ppm	X				
Gas detection in fuel supply pipe ducting or secondary enclosure at 300 ppm	X				X(2)
Loss of ventilation in machinery space	X				
Gas detection at vent mast exit at 300 ppm	X				
Gas detection at engine exhaust exit(s) at 10 ppm	X				
Gas detection at engine exhaust exit(s) at 50 ppm	X				X

Parameter	*Alarm*	*Automatic activation of water screens, and increased ventilation*	*Automatic shutdown of tank valve*	*Automatic shutdown of the bunker manifold ESD valves(1)*	*Automatic shutdown of fuel supply to machinery space containing consumers*
Gas detection at crankcase breather, or under piston space, exit(s) at 10 ppm	X				
Gas detection at crankcase breather, or under piston space, exit(s) at 50 ppm	X				X
Ammonia leaks to auxiliary system	X(3)				
Gas detection at ventilation inlets and openings to accommodation spaces, service spaces and control stations at 25 ppm	X				
Gas detection at ventilation inlets and openings to accommodation spaces, service spaces and control stations at 50 ppm	X(4)				
Gas detection at bunker station at 150 ppm	X				
Gas detection at bunker station at 300 ppm	X			X	
Manual Emergency Shut Down	X	X	X	X	X

Commentary:

1 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.

2 Double block and bleed and Master Fuel Valves to close.

3 At the locations indicated by 9/5.13 and 10/3.2 of this Guide.

4 To close the self-closing devices referenced by 13/3.3 of this Guide.

End of Commentary

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 Guide.

1.3

The manufacture, testing, inspection and documentation is to be in accordance with 5C-13-16 and Part 7 of the *Marine Vessel Rules*.

1.4

Survey During Construction:

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

1.5

Survey After Construction:

1.5.1 Annual Survey

For annual survey, the survey is to include applicable sections of 7-6-2/1.7 and 7-6-2/1.9 of the *Marine Vessel Rules*.

Additionally, annual survey is to include:

1) Functional testing of water screens above access doors for fuel preparation room.

2) Functional testing of gas evacuation system for fuel preparation room.

3) Functional testing of alarms for monitoring and safety functions [15/Table 1].

4) Functional testing of eyewash and decontamination showers.

5) Operational testing of fuel treatment or vent control systems utilizing water scrubbing or treatment systems.

6) Operational testing of associated exhaust aftertreatment systems.

7) Testing of portable gas detectors for ammonia.

8) Testing of fixed gas detection for ammonia.

9) Testing of gas detection:

a) 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) [9/5.14].

b) at crankcase breather, or under piston space [10/3.5].

c) where the engine auxiliary systems are likely to contain ammonia in abnormal conditions as a result of a component failure (refer to FMEA for more information) [10/3.7].

10) Examination of toxic areas and ventilation intakes including gas detection system for ammonia.

11) Examination of all other personnel safety and PPE specific to ammonia [5/11].

1.5.2 Intermediate Surveys

For intermediate surveys, the survey is to include applicable sections of 7-3-2/3.1.8 of the *Marine Vessel Rules*.

1.5.3 Special Periodical Surveys

For special surveys, the survey is to include applicable sections of 7-6-2/3.7 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

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*.

SECTION 18
Operation

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 of this Guide.