Guidelines on

Ammonia Fueled Vessels

December 2022

IRCLASS

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Guidelines

Ammonia Fueled Vessels

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Section 1

Introduction

With a view to promote the use of alternative fuels in shipping in order to reduce greenhouse gases emissions, use of ammonia as fuel is being encouraged by Governments.

These guidelines are intended to provide requirements for ships using ammonia as fuel in the liquid state in storage tanks.

The basic philosophy of these guidelines is to provide provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems in ships using ammonia as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

Throughout the development of these guidelines it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available of current operational experience, field data and research and development.

These guidelines address all areas that need special consideration for the usage of the ammonia as fuel. These guidelines consider the goal based approach (MSC.1/Circ.1394). Therefore, goals and functional requirements were specified for each section forming the basis for the design, construction and operation.

The current version of these guidelines includes requirements to meet the functional requirements for ammonia as fuel.

These guidelines have been developed in order to assist the ship owners, ship designers and shipyards in designing, building and operating ammonia fueled vessels.

Section 2

General

2.1 Application

2.1 Unless expressly provided otherwise these guidelines apply to ships of 500 GT and above using ammonia as fuel . In the case of ships of less than 500 GT, requirements will be specially considered based on individual designs and risk assessments.

2.2 Notations

2.2.1 Ship using Ammonia as fuel, complying with the requirements of these guidelines or complying with the alternative design requirements in Cl. 2.3.3 of Pt.5, Ch.35 of *Rules and Regulations for the Construction and Classification of Steel Ships* (hereinafter referred to, as the Main Rules) will be assigned with notation **LFPF(AM)**. In the above mentioned notation **(AM)** is an additional qualifier notation indicating the usage of Ammonia as fuel.

2.2.2 Following additional notation will be assigned as applicable:

(SFE) – Ships with single fuel engines using natural gas or other low flash point fuel.

(DFE) – Ship using dual fuel engines

2.3 Definitions

Unless otherwise stated below, definitions of various terms are as defined in SOLAS Chapter II-2 and Section 2.2 of Part 5, Chapter 35 of the Main Rules.

2.3.1 *Engine Room* means a machinery space containing ammonia fueled engine(s)

2.3.2 *Fuel* means anhydrous ammonia in its liquefied or gaseous state. The term “fuel” and “ammonia” used in these guidelines refer to anhydrous ammonia.

2.3.3 *Fuel tank* is any integral, independent or portable tank used for storage of fuel. The spaces around the fuel tank are defined as follows:

.1 *Fuel storage hold space* is the space enclosed by the ship´s structure in which a fuel tank is situated. If tank connections are located in the fuel storage hold space, it will also be a tank connection space. Integral fuel tanks do not have a fuel storage hold space;

.2 *Cofferdam* for fuel tanks is a structural space surrounding a fuel tank which provides an added layer of vapour tight protection against toxic and flammable vapours between the fuel tank and other areas of the ship;

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.3 *Tank connection space* is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.

2.3.4 *Fuel preparation room* means any space containing equipment for fuel preparation purposes, such as fuel pumps, fuel valve train, heat exchangers and filters.

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

2.3.6 *Gas freeing* is the process carried out to achieve a safe tank atmosphere. It includes two distinct operations:

.1 Purging the hazardous tank atmosphere with an inert gas or other suitable medium (e.g. water) to dilute the hazardous vapour to a level where air can be safely introduced;

.2 Replacing the diluted inert atmosphere with air.

2.3.7 *Gross Tonnage* means the measure of the overall size of a ship determined in accordance with the provisions of the *International Convention on Tonnage Measurement of Ships, 1969*.

2.3.8 *Independent tanks* are self-supporting, do not form part of the ship's hull and are not essential to the hull strength.

2.3.9 *Integral tank* means a tank which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

2.3.10 *Portable tank* means an independent tank being able to be:

– easily connected and disconnected from ship systems; and

– easily removed from ship and installed on board ship.

2.3.11 *Purging* means the introduction of inert gas into a tank to reduce the oxygen level so that combustion is not supported; continued purging can reduce the quantity of hydrocarbon vapours to below the LEL such that combustion will not be supported if air is subsequently introduced to the tank.

2.3.12 *Single failure* is where loss of intended function occurs through one fault or action.

2.3.13 *Single fuel engine* means an engine capable of operating on ammonia on one fuel only.

2.3.14 *Fuel Containment System*: is the arrangement for the storage of fuel including tank connections.

2.3.15 *Unacceptable loss of power:* means that it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative, in accordance with SOLAS regulation II-1/26.3.

2.3.16 *Toxic Areas* are areas where ammonia toxicity risk from potential leak sources exist.

2.3.17 *Bunkering:* means the transfer of ammonia fuel from land-based or floating facilities into ship’s permanent tanks or connection of portable tanks to the fuel supply system.

2.4 Alternative Design

2.4.1 These guidelines contain functional requirements for all appliances and arrangements related to the usage of ammonia fuel.

2.4.2 Appliances and arrangements of fuel systems may deviate from those set out in these guidelines, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant sections.

2.4.3 The equivalence of the alternative design is to be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by these guidelines would not be acceptable.

2.4.4 Liquefied gas carriers carrying ammonia are not allowed to use ammonia as fuel due to its toxicity (Refer Pt 5, Ch. 4, Sec 16.9.2 (IGC Code)). Relevant Flag Administration is to be consulted to consider the possibility of using ammonia as fuel and suitable approval process is to be followed.

2.4.5 For ships other than liquefied gas carriers intending to use ammonia as fuel, Pt. 5, Ch. 35, Sec 2.3 may be referred which requires an alternative design approach to be performed. The first step in this process is a preliminary Hazard Identification (HAZID) study at the preliminary design phase of the project to identify high level risk. This HAZID supports the Alternative Design process and follows established risk assessment methodologies to satisfy the IGF Code risk assessment requirements (for ammonia as fuel) detailed under 4.2.1 and 4.2.3 of the Pt. 5, Ch. 35 (IGF Code).

2.5 Documentation Requirements

2.5.1 For a ship with ammonia engine installations, plans and documents are to be submitted for approval as listed in the following:

.1 Documentation related to the design, testing and operation as applicable:

a) Design statement that provides information about the intended service of the ship, including a description of the arrangements, essential services and the intended operating capability and functionality of the main propulsion and auxiliary systems that use ammonia as fuel.

b) Operating manuals that indicate the installation particulars, including operating and maintenance instructions. Equipment manufacturers' instructions are to include the drawings and diagrams necessary for putting into service, maintenance, inspection, checking of correct operation, repair of the machinery, the use of correct spares and tools, and useful instructions with regard to safety.

c) Quality plans for sourcing, design, installation and testing of all components and equipment used in the fuel system.

d) Evidence of type testing of the engine with electronic controls or a proposed test plan at the builders with the electronic controls operational, to verify suitability of the electronic control system and correct functioning during normal operation and identified failure modes.

e) Schedule of testing at engine builders and commissioning prior to sea trials, to demonstrate that various consumers are capable of operating as described in the design statement, including any testing required to verify the safeguards determined in the risk-assessment. The test schedules are to identify all modes of operation and the sea trials are to include typical manoeuvres under all intended engine operating modes.

f) Documentation for Control and Monitoring of the fuel system including safety system, interfaces to other safety and control systems.

g) Bunkering operational procedures and maintenance instruction manuals.

h) Fire Safety operational documentation including ammonia safety / emergency procedures.

i) Testing and trial procedure (including sea trials). The testing procedures should include testing of safety shutdowns in accordance with the cause and effect diagram. The cause and effect diagram is to indicate the results of activation of each shutdown, shut-off and cut-out associated with the fuel system including engine operation and bunkering.

.2 Arrangement plan of the ship indicating the following, as applicable:

a) machinery and boiler spaces, accommodation spaces, service spaces and control station spaces.

b) fuel tanks and containment systems

c) fuel preparation spaces

d) fuel bunkering pipes with shore connections

e) tank hatches, ventilating pipes and any other openings to fuel tanks

f) ventilating pipes, door and openings to fuel preparation room, double walled piping and other hazardous areas

g) entrances, air inlets and openings to accommodation spaces, service spaces and control station spaces

h) Air lock arrangements

.3 Plans and documents of the fuel tanks covering the following details, as applicable:

a) tank hatches, pipes and any openings to tanks
b) supports and stays
c) insulation
d) Independent Tanks: specification of design loads and structural analysis of fuel tanks
e) Integral Tanks: hull structural analyses
f) tank connection space arrangement
g) tank hatches, pipes and any openings to the gas tanks
h) purging and gas freeing system, including safety relief valves and associated piping
i) fabrication details of independent tanks including building tolerances, NDT plan and welding procedures (WPS)

.4 Plans and documentation showing arrangement and details of piping systems covering the following, as applicable:

a) vent lines for pressure/ vacuum relief valves or similar piping and ducts for fuel pipes
b) electrical bonding for piping
c) fuel heating and cooling system
d) exhaust gas system, including arrangement of explosion relief
e) drip tray and coaming arrangement
f) functional testing procedure of all piping systems including valves, fittings and associated equipment for handling fuel.
g) Control and monitoring system documentation for ventilation systems.

.5 Hazardous area Classification plan

.6 Toxic Area Classification Plan

.7 Electrical schematic drawing, including single line diagrams for all intrinsically safe circuits including explosion protection details of components.

.8 Plans and Documentation for Fire safety as listed in the following:

a) Gas detection and alarm system
b) Fire detection and alarm system
c) Fire extinguishing equipment
d) Structural fire protection plan
e) Control and monitoring system documentation for:

- Gas detection and alarm system
- Fire detection and alarm system

f) Fixed fire extinguishing system documentation, containing details on:

- External surface protection water spraying system
- Bunkering station fire extinguishing system

2.6 Properties of Ammonia

2.6.1 Table 2.6.1 indicates important properties of ammonia, vis-à-vis current and other future fuels. The Table may be used for guidance purposes only and is not to be considered as fuel standard. Further, Table 2.6.2 provides information on the health implications caused by exposure to ammonia.

Table 2.6.1 - Properties of Ammonia and some of the other existing fuels and future fuels
(*Source: Maritime Cleantech*)

	Boiling point (^{0}C at 1 bar)	Density (kg/m$_3$)	Specific energy LHV (MJ/kg)	Specific energy LHV (kWh/kg)	Energy density (MJ/m$_3$)	Storage temperature / pressure	Chemical composition
MGO	175-650	890	42.7	11.97	38,000	Ambient / atmospheric	Hydrocarbon
LNG	-162	440	50	12.5	22,000	Cryogenic /Atmospheric/ Low pressure	CH_4
LPG (Propane)	-42	490	46.4	12.9	22,740	Amb. Or Cryogenic / Atm.	C_3H_8
Ammonia (liquid)	-33.3	653.1	18.6	5.17	14,100	Ambient High / Atm. pressure	NH_3
Methanol	65	780	20	5.56	36,700	Ambient Atm.	CH_3OH

Table 2.6.2 Health implications according to ammonia concentration and exposure time
(*Source: US Environmental Protection Agency, Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 6*)

	Exposure Time				
AEGL Level	**10min**	**30min**	**60min**	**240min**	**480min**
AEGL1	30 ppm	30 ppm	30 ppm	30 ppm	30 ppm
AEGL2	220 ppm	220 ppm	160 ppm	110 ppm	110 ppm
AEGL3	2700 ppm	1600 ppm	1100 ppm	550 ppm	390 ppm

Notes:-
AEGL : Acute Exposure Guideline Level
AEGL 1: Causes irritation but is recoverable immediately when the exposure is stopped
AEGL 2: Cause irreversible or long-lasting health hazards
AEGL 3: Fatal

Section 3

Goal and Functional Requirements

3.1 Goal

3.1.1 The goal of these guidelines is to provide for safe and environmentally-friendly 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.

3.2 Functional Requirements

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

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

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

3.2.4 Hazardous areas are to be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board and equipment.

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

3.2.6 Unintended accumulation of explosive, flammable or toxic vapour and liquid concentrations is to be prevented.

3.2.7 System components are to be protected against external damage.

3.2.8 Sources of ignition in hazardous areas are to be minimized to reduce the probability of fire and explosions.

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

3.2.9.1The 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).

3.2.9.2 Where venting 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.

3.2.9.3 For the purposes of venting, “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. Anhydrous ammonia is extremely harmful to aquatic life, so relief or direct discharge to seawater is to be avoided.

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

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

3.2.12 Fuel containment system and machinery spaces containing source that might release gas into the space is to 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.

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

3.2.14 Fixed fuel vapour and/or leakage detection suitable for all spaces and areas concerned are to be arranged.

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

3.2.16 Commissioning, trials and maintenance of fuel systems and fuel utilization machinery are to be satisfy the goal in terms of safety, availability and reliability.

3.2.17 The technical documentation is to 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.

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

3.2.19 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.

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

Section 4

General Requirements

4.1 Goal

4.1.1 The goal of this Section is to ensure that the necessary assessments of the risks involved are carried out in order to eliminate or mitigate any adverse effect on the persons on board, the environment or the ship.

4.2 Risk Assessment

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

4.2.2 The risks are to be analyzed using acceptable and recognized risk analysis techniques. Loss of function, component damage, fire, explosion, toxicity and electric shock are to be as a minimum be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary. Details of risks, and the means by which they are mitigated, are to be documented to the satisfaction of IRS/ the Administration. At least the following risks are to be considered:

- Loss of function
- Component damage
- Fire
- Explosion
- Collision
- Grounding
- Intoxication
- Chemical burning
- Pollution
- Variation of bunkered ammonia fuel characteristics (temperature)
- Rollover

The analysis is to ensure that risks are ALARP (As Low As Reasonably Practicable).

4.2.3 A dispersion analysis to establish the fuel dispersion (whilst venting/ leakage during bunkering) is to be carried out. This assessment is to cover the whole bunkering system, including the bunkering source and is to allow the definition of the dangerous areas around the bunkering stations.

4.2.4 The risk assessment is to cover the possible liquid and gaseous ammonia fuel leakages and spills and their consequences during the ship operation including bunkering, in particular with respect to:

- the accumulation of ammonia vapours in spaces containing a potential source of ammonia release and their spreading over the ship's spaces through non-gastight openings

- the spreading of ammonia vapours from the vent mast outlet on open decks and their possible recirculation to accommodation through openings and ventilation inlets

- the formation of ammonia vapour cloud in the vicinity of the ship or in remote locations, taking into account the ambient conditions (e.g. humidity)

- the heat release in case of ammonia dissolution in water

- the draining of the hold space in case of independent tank failure.

4.2.5 The risk analysis is to cover at least the following spaces, zones and systems:

- storage tanks
- tank hold spaces
- tank connection space (TCS)
- fuel preparation rooms
- bunkering stations
- spaces containing liquid or gaseous ammonia piping
- vent mast.

The ammonia spreading scenarios in case of leakage are to be analyzed.

4.2.6 The risks identified by the HAZID study may be mitigated by operational measures when design options have all been shown not to be reasonably practicable.

4.3 Limitation of Explosion Consequences

4.3.1 To limit the consequences of an explosion in any space containing any potential of release of flammable vapor/liquid and potential ignition sources, Pt.5, Ch.35, 4.3 of the Main Rules is applicable. (Note: Double wall fuel pipes are not considered as potential sources of release)

Section 5

Ship Design and Arrangement

5.1 Goal

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

5.2 Functional Requirements

5.2.1 The functional requirements in Section 3 of this document and those specified in Pt.5, Ch.35, Section 5.2 of the Main Rules are applicable.

5.3 General

5.3.1 The fuel containment protection requirements of Pt.5, Ch.35, Section 5.3 of Main Rules are applicable.

5.4 Machinery Space Concepts

5.4.1 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 Pt.5, Ch.35, Cl. 5.4.1.1 of Main Rules is to be applied to all machinery spaces containing ammonia consumers.

'ESD machinery space' concept mentioned in IGF Code and Pt.5, Ch.35 of Main Rules is not to be applied for ammonia as fuel installations. Accordingly, all references to Pt.5, Ch.35 of Main Rules from this Guidelines, that may include the 'ESD machinery space' concept requirements, are not applicable.

5.4.2 All fuel piping within machinery space boundaries is to be enclosed in vapour/ gas tight and liquid tight enclosures in accordance with Pt.5, Ch.35, Cl. 9.6 of Main Rules.

5.4.3 Machinery spaces containing ammonia fuel consumers are to be arranged for remote monitoring in accordance with the requirements for **SYJ** notation of the Main Rules.

5.5 Requirements for Location and Protection of Fuel Piping

5.5.1 Fuel pipes are to be located and protected in accordance with Pt.5 Ch.35, Cl.5.7.1 to 5.7.3 of Main Rules.

5.6 Requirements for Fuel Preparation Room Design

5.6.1 A dedicated fuel preparation room/ space is to be provided for locating the following:

a) Equipment and systems for ammonia fuel supply; and

b) Equipment for compression, re-liquefaction or cooling of ammonia in the fuel tanks, as applicable

Fuel preparation rooms/ spaces which may contain potential sources of release, such as 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.

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

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

5.6.4 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.

5.6.5 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.

5.6.6 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.

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

5.6.8 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 . One of the means of escape may be a vertical ladder through a hatch to the weather deck. 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.

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

5.7 Requirements for Bilge Systems

5.7.1 Bilge system design and arrangements are to be in accordance with Pt.5, Ch.35, 5.9 of Main Rules.

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

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

5.7.4 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.

5.7.5 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 Pt.5, Ch.3, 15.12.3 of Main Rules. Anhydrous ammonia is extremely harmful to aquatic life, so relief or direct discharge to seawater is to be avoided.

5.7.6 In spaces where a water mist system is installed, the number and diameter of the scupper pipes or bilge suctions are to be sufficient to avoid any risk of water accumulation.

5.7.7 Bilge water holding tanks and drain tanks likely to contain dissolved ammonia are to be

a) located outside the machinery spaces and provided with a vent pipe led to the vent mast with means of ammonia vapor detection and;
b) are to be surrounded by cofferdam, except on those surfaces bound by ammonia preparation room.

5.8 Requirements for Drip Trays

5.8.1 Drip tray design and arrangements, as applicable to ammonia, are to be in accordance with Pt.5, Ch.35, Cl.5.10 of Main Rules.

5.9 Requirements for Arrangement of Entrances and other Openings in enclosed Spaces

5.9.1 Arrangements of entrances and other opening in enclosed spaces are to in accordance with Pt.5, Ch.35, Cl.5.11.1 to 5.11.3 and Cl.5.11.5 of the Main Rules

5.9.2 Access to the space containing a potential source of ammonia release should not be necessary in normal operational condition of the ship (except in the case of the bunkering stations, for which access is necessary for connecting and disconnecting the ammonia transfer hoses). The access to the space is to be provided with locking arrangements which is to be under the control of the responsible ship's officer. A procedure is to be available onboard specifying the conditions to be observed for safe access to the space. A warning notice with safety instructions is to be provided outside the space, adjacent to each access door.

5.10 Requirements for Air Locks

5.10.1 Airlocks are to be in accordance with Pt.5, Ch.35, Cl. 5.12 of Main Rules.

5.11 Personnel Safety and PPE

5.11.1 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.

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

5.11.3 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 Section 4 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.

5.11.4 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 1200 litres 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.

5.11.5 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 Cl. 5.11.3

ii) an air compressor 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 Cl. 5.11.3.

5.11.6 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/ authorised service supplier at least once a year.

5.11.7 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 (Note: The risk assessment required by Section 4 is to specifically consider the need for additional duration.)

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 Section 4 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.

5.11.8 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.

5.11.9 The ship is to be provided with at least two sets of portable ammonia gas detectors that comply with a recognised national or international standard.

Section 6

Fuel Containment System

6.1 Goal

6.1.1 The goal of this Section is to provide for a fuel containment system where the risk to the ship, person on board and to the environment is minimized to a level that is at least equivalent to a conventional oil fueled ship.

6.2 Functional Requirements

6.2.1 The functional requirements in Section 3 of this document and functional requirements specified in Pt.5, Ch.35, Section 6, Cl.6.2 of Main Rules are applicable.

6.3 General

6.3.1 The general fuel containment requirements of Pt.5, Ch.35, Cl.6.3.2 to 6.3.12 of Main Rules, as applicable to the storage of ammonia, apply.

6.4 Fuel Containment

6.4.1 Fuel storage tanks are to be designed in accordance with Part 5, Ch.4, Sec.4 of Main Rules for liquefied or pressurized ammonia fuel containment.

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

6.4.3 The fuel storage tank types defined in Part 5, Ch.4, Cl.4.21 to 4.26 of the Main Rules are to be provided with secondary barriers in accordance with the following:

Membrane Tank :– Complete Secondary Barrier

Type A Tank :- Complete Secondary Barrier

Type B Tank :- Partial Secondary barrier

Type C Tank:- No Secondary Barrier

6.4.4 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 Pt.5, Ch.4, Cl.17.12.2 to 17.12.8 of Main Rules are to be taken, as appropriate.

6.4.5 Materials of construction such as aluminium and austenitic stainless steel may be applied in ammonia service as permitted by Pt.5, Ch.35, Sec.7 of Main Rules. Subject to review and agreement of IRS, 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.

6.5 Portable Tanks

6.5.1 Portable fuel tanks are to be arranged in accordance with Pt.5, Ch.35, Cl.6.5 of Main Rules.

6.6 Pressure relief system

6.6.1 Pressure relief valves and systems in accordance with Pt.5, Ch.35, Cl.6.7.1 to 6.7.3 of Main Rules are to be provided.

6.6.2 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.

6.6.3 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.

6.6.4 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.

6.6.5 Fuel storage hold spaces, inter-barrier 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 Cl.6.8.1.

6.7 Loading limits for ammonia fuel tanks

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

6.7.2 The maximum loading limit (LL) to which a fuel tank may be loaded is to be determined in accordance with the formula given in Pt.5, Ch.35, Cl.6.8.1 of Main Rules. A loading limit curve for the actual fuel loading temperatures is to be prepared.

6.8 Maintenance of fuel storage condition

6.8.1 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 Pt.5, Ch.35, Cl.6.9.1 and 6.9.4 of Main Rules. The 15 day criteria for maintaining tank pressure below the set pressure of the relief valve detailed under Pt.5, Ch.35, Cl.6.9.1 of Main Rules, is to be considered at all tank fill conditions.

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

6.8.3 The design and availability of systems for maintaining fuel storage condition are to be in accordance with Pt.5, Ch.35, Cl.6.9.2 and 6.9.6 of Main Rules.

6.8.4 Reliquefaction systems

6.8.4.1 The dedicated fuel reliquefaction and refrigeration systems are to be designed in accordance with Main Rules, Pt.5, Ch.35, Cl.6.9.3.

6.8.4.2 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.

6.9 Atmospheric Control within the Fuel Containment System

6.9.1 Provision to enable each fuel tank to be gas-freed are to be provided in accordance with Pt.5, Ch.35, 6.10 of Main Rules.

6.10 Atmospheric Control within Fuel Storage Hold Spaces

6.10.1 Atmospheric control arrangements for inter-barrier 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 Pt.5, Ch.35, Cl.6.11 of Main Rules.

6.10.2 Atmospheric control arrangements for fuel storage hold spaces surrounding Type C independent tanks are to be in accordance with Pt.5, Ch.35, Cl.6.12 of Main Rules.

6.11 Inert Gas Availability on Board

6.11.1 Inert gas arrangements are to be in accordance with Pt.5, Ch.35, Cl.6.13 of Main Rules.

6.11.2 Where inert gas is produced on board, the production and storage arrangements are to be in accordance with Pt.5, Ch.35, Cl.6.14 of Main Rules.

Section 7

Material and General Pipe Design

7.1 Goal

7.1.1 The goal of this Section is to ensure the safe 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.

7.2 Functional Requirements

7.2.1 The functional requirements in Section 3 of this document and those specified in Pt.5, Ch.35, Section 7, 7.2 of Main Rules are applicable.

7.3 General Pipe Design

7.3.1 Fuel pipe design and arrangements are to be in accordance with Pt.5, Ch.35, Cl. 7.3 of Main Rules.

7.4 Requirements for Materials

7.4.1 In general, requirements for materials are to be in accordance with Part 2 of the Main Rules.

7.4.2 Materials for fuel containment, fuel piping and process pressure vessels are to be in accordance with Pt.5, Ch.35, Cl. 7.4 of Main Rules.

7.4.3 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.

7.4.4 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 Pt.5, Ch.4, Cl.17.12.2 to 17.12.8 of Main Rules are to be taken, as appropriate.

7.4.5 Materials of construction such as aluminum and austenitic stainless steel may be applied in ammonia service as permitted by Pt.5, Ch.35, Section 7 of the Main Rules. Subject to review and agreement of IRS, 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.

7.4.6 In addition, mercury, cadmium, copper, zinc or alloys of these materials are not to be used as 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.

7.4.7 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 IRS, 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

8.1 Goal

8.1.1 The goal of this Section is to provide for suitable systems on board the ship to ensure that bunkering can be conducted without causing danger to persons, the environment or the ship.

8.2 Functional Requirements

8.2.1 The functional requirements of Section 3 of this document and those specified in Pt.5, Ch.35, Section 8, Cl.8.2 of Main Rules are applicable.

8.2.2 Bunkering system is to be designed to prevent venting under all normal operating conditions including idle periods.

8.3 Requirements for Bunkering Station

8.3.1 Bunkering station arrangements are to be in accordance with Pt.5, Ch.35, Cl.8.3 of Main Rules.

8.4 Requirements for Manifold

8.4.1 Bunkering manifold arrangements are to be in accordance with Pt.5, Ch.35, Cl.8.3 of Main Rules.

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

8.4.3 The bunkering manifold is to be designed to withstand the external loads during bunkering. The connections at the bunkering station are to be of dry-disconnect type equipped with additional safety dry break-away coupling/self-sealing quick release.

8.5 Requirements for Bunkering System

8.5.1 Bunkering system arrangements are to be in accordance with Pt.5, Ch.35, Cl.8.5 of Main Rules.

8.6 Gas Detection

8.6.1 All bunker stations and ventilated ducts, or double wall piping systems, around fuel bunker pipes are to be fitted with permanently installed gas detectors for leak detection, suitable for flammability and toxicity, in accordance with Cl.15.8.

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

Section 9

Fuel Supply to Consumers

9.1 Goal

9.1.1 The goal of this Section is to ensure safe and reliable distribution of fuel to the consumers.

9.2 Functional Requirements

9.2.1 The functional requirements in Section 3 of this document and those specified in Pt.5, Ch.35, Section 9.2 of Main Rules are applicable.

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

9.3 General Requirements for Fuel Supply System

9.3.1 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. Depending on the specific arrangements, reference may also need to be made to the requirements for re-liquefaction components and systems given under Cl.6.8.4.

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

9.4 Redundancy of Fuel Supply

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

9.4.2 The propulsion and auxiliary arrangements and fuel supply systems are to be arranged so that in 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 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.

9.5 Safety Functions of the Fuel Supply System

9.5.1 All fuel piping is to be arranged for gas-freeing 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 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.

9.5.2 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.

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

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

9.5.5 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.

9.5.6 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 Cl.9.5.3.

9.5.7 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.

9.5.8 Each consumer is to be provided with a "double block and bleed" valve arrangement. These valves are to be arranged as indicated 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 the fail-to-close type, while 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 Pt.5, Ch.35, Cl.10.3.1.15 of the Main Rules and are to be considered in the risk assessment required by Cl.4.2.

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

9.5.10 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.

9.5.11 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.

9.5.12 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. The combined master fuel valve and block valve are to be located outside the machinery space, as required by Cl.9.5.5. 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.

9.5.13 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.

9.5.14 As applicable, where the auxiliary heat exchange circuits are likely to contain ammonia in abnormal conditions as a result of a component failure (Cl.10.3.2), 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.

9.6 Fuel Distribution Outside of Machinery Spaces

9.6.1 Fuel piping systems outside of machinery spaces are to be arranged in accordance with Pt.5, Ch.35, Cl.9.5 of Main Rules.

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

9.7.1 Fuel piping systems in gas safe machinery spaces containing consumers are to be arranged in accordance with Pt.5, Ch.35, Cl. 9.6 of Main Rules.

9.8 Design of Fuel Piping Ventilated Duct or Outer Pipe

9.8.1 The design of the fuel piping ventilated duct or outer pipe is to be in accordance with Pt.5, Ch.35, Cl. 9.8 of Main Rules

9.9 Compressors and Pumps

9.9.1 Compressors and pumps are to be in accordance with Pt.5, Ch.35, Cl. 9.9 and 9.11 of the Main Rules.

9.10 Vaporizers, Heat Exchangers and Pressure Vessels

9.10.1 Vaporizers, heat exchangers and pressure vessels are to be arranged, as applicable, in accordance with Pt.5, Ch.35, Cl. 9.10 of the Main Rules.

9.11 Ancillary Systems

9.11.1 The design of the fuel supply ancillary systems is to be in accordance with Pt.5, Ch.35, Cl. 9.12 of the Main Rules.

Section 10

Power Generation including Propulsion and other Energy Consumers

10.1 Goal

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

10.2 Functional Requirements

10.2.1 The functional requirements in Section 3 of this document and functional requirements specified in Pt. 5, Ch.35, Section 10.2 of Main Rules are applicable.

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

10.3 General

10.3.1 The requirements specified in this section are additional to all other relevant requirements of the Main Rules.

10.3.2 Internal combustion engines intended to use ammonia as fuel are to be designed, tested and certified in accordance with Pt.4 Ch. 4, Sec.4, Pt. 5, Ch. 4, Sec.16 and Pt. 5, Ch. 35, Sec. 10, as applicable, of Main Rules. The fuel specification required by the engine is to be declared by the manufacturer and detailed in the operation and maintenance manuals.

10.3.3 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.

10.3.4 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.

10.3.5 Internal combustion engines, and as applicable, associated exhaust after treatment systems, are to be designed such that ammonia (NH_3) content in the exhaust gas does not exceed 10 ppm. Monitoring of exhaust(s) is to be in accordance with Section 15.

10.3.6 The design of internal combustion engines is to be in accordance with Pt.5, Ch.35, Cl.10.1.1, 10.3.1.1 to 10.3.1.3 and Cl.10.3.1.5 to 10.3.1.7, as applicable, of the Main Rules.

10.3.7 As applicable, where the engine auxiliary systems are likely to contain ammonia in abnormal conditions as a result of a component failure (also refer Cl. 10.3.9 and 10.3.2), 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.

10.3.8 The engine transient response characteristics are to be appropriate for the intended application. Engines driving generators are to meet the transient response requirements of Pt.4, Ch.4, Section 4.7 of the Main Rules.

10.3.9 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 IRS Classification Note: *Approval of IC Engines*. 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.

10.4 Dual-Fuel Engines

10.4.1 Dual fuel internal combustion engines are to be arranged in accordance with Pt.5, Ch.35, Cl. 10.3.2 of Main Rules.

10.4.2 Dual fuel internal combustion engine type testing is to include verification of the exhaust and crankcase breather, or under piston space, limits of Cl.10.3.5.

10.5 Fuel Cells

10.5.1 Fuel cell systems using ammonia are to comply with the relevant requirements given in IRS Guidelines on *Vessels with Fuel Cell Power Installations*.

Section 11

Fire Safety

11.1 Goal

11.1.1 The goal of this Section is to provide fire protection, detection and fighting for all systems related to storing, handling, transfer and use of ammonia as fuel.

11.2 Functional Requirements

11.2.1 The functional requirements in Section 3 of this document and those specified in Pt.5, Ch.35, Section 11.2 of the Main Rules are applicable.

11.3 General Requirements

11.3.1 The requirements in this Section are additional to those given in SOLAS Ch. II-2.

11.4 Fire Protection

11.4.1 The fire protection requirements specified in Pt.5, Ch.35, Cl.11.3.1 to 11.3.6 of Main Rules are applicable.

11.5 Fire Main

11.5.1 The fire main is to be arranged in accordance with Pt.5, Ch.35, Cl.11.4 of Steel Ship Rules.

11.6 Water Spray System

11.6.1 The water spray system is to be arranged in accordance with Pt.5, Ch.35, Cl.11.5 of Main Rules.

11.6.2 In addition to the water spray system providing coverage for the fuel tanks, and the additional locations required by Pt.5, Ch.35, Cl.11.5.2 of Main 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.

11.6.3 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 Cl.11.6.1. With respect to application of Pt.5, Ch.35, Cl.11.5.2 of Main Rules, the system is to be provided regardless of the distance of the bunker station from the fuel tank.

11.6.4 Water based firefighting systems are not to be used on liquid ammonia fire.

11.7 Dry chemical powder fire-extinguishing system

11.7.1 The bunker station fire-extinguishing system is to be arranged in accordance with Pt.5, Ch.35, Cl.11.6 of Main Rules.

11.8 Fire detection and alarm system

11.8.1 The fire detection and alarm systems are to be arranged in accordance with Pt.5, Ch.35, Cl.11.7 of Main Rules.

11.9 Fire Extinguishing of Engine-Room and Fuel Preparation Room

11.9.1 Machinery space and fuel preparation room where ammonia fueled engines or fuel pumps are arranged are to be protected by an approved fixed fire extinguishing system in accordance with SOLAS Reg.II-2/10 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 and Area Classification

12.1 Goal

12.1.1 The goal of this Section is to provide for the prevention of explosions and for the limitation of effects of a fire and explosion.

12.2 Functional Requirements

12.2.1 The functional requirements specified in Cl.3.2 of this document and those in Pt.5, Ch.35, Cl.12.2 of Main Rules are applicable. 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.

12.3 General Requirements

12.3.1The requirements of Pt.5, Ch.35, Cl.12.3.1 to 12.3.2 of Main Rules are applicable.

12.3.2 All hazardous areas are to be inaccessible to passengers and unauthorized crew at all times.

12.4 Area Classification

12.4.1 The hazardous area classification requirements of Pt.5, Ch.35, Cl.12.4 and Pt.4, Ch.8, Sec.11 of Main Rules are applicable.

12.5 Hazardous Area Zones

12.5.1 Hazardous area zone 0

12.5.1.1 This zone includes, but is not limited to:

.1 the interiors of fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing fuel.

12.5.2 Hazardous area zone 1
(Note: Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 1)

12.5.2.1 This zone includes, but is not limited to:

.1 tank connection spaces, and fuel storage spaces and inter-barrier spaces;

.1.1 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.

.2 fuel preparation room;

.3 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 ;

.4 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 ;

.5 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;

.6 other enclosed spaces where leakage of ammonia may occur

12.5.3 Hazardous area zone 2
(Note: Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 2)

12.5.3.1 This zone includes, but is not limited to:

.1 areas 4 [m] beyond the cylinder and 4 [m] beyond the sphere defined in Cl.12.5.2

.2 areas within 1.5 [m] surrounding open or semi-enclosed spaces of zone 1;

.3 air locks; and

.4 space containing bolted hatch to tank connection space.

12.6 Toxic Areas

12.6.1 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.

12.6.2 The criteria throughout these Guidelines support 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.

12.6.3 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.

12.6.4 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) areas on open deck, or semi-enclosed spaces on deck within 10 m from

a) any fuel tank outlet, gas or vapor outlet, 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;

b) spillage coamings surrounding bunker manifold valves;

c) fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into Hazardous Zone 1 spaces.

12.6.5 Such potentially toxic areas are to be specially considered by the risk assessment required by Cl. 4.2. A gas dispersion analysis would 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

13.1 Goal

13.1.1 The goal of this Section is to provide for the ventilation required for safe working conditions for personnel and the safe operation of machinery and equipment where ammonia is used as fuel.

13.2 Functional Requirements

13.2.1 The functional requirements detailed in Subsection 3.2 of this Guideline and Pt.5, Ch.35, Section 13.2 of Main Rules are applicable.

13.3 General

13.3.1 Ventilation design and arrangements are to be in accordance with Pt.5, Ch.35, Cl. 13.3 of Main Rules.

13.3.2 The ventilation arrangements are to take into account the density of any potential releases of ammonia. While gaseous anhydrous ammonia is lighter than air, it is hygroscopic and therefore readily absorbs moisture. Releases in the air may form vapours that are heavier than air. Therefore, ventilation outlets are to be provided both in the lowest and highest parts of the space and suitably protected.

13.3.3 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), 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.

13.3.4 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.

13.4 Tank Connection Space

13.4.1 The tank connection space arrangements are to be in accordance with Pt.5, Ch.35, Cl. 13.4 of Main Rules.

13.5 Requirements for Fuel Preparation Room

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

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

13.5.1.2 The number and power of the ventilation fans 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.

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

13.5.1.4 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.

13.5.1.5 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.

13.5.1.6 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.

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

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

13.5.1.9 Design of ventilation fans serving the fuel preparation room are also to be in accordance with Pt.5, Ch.2, Cl.6.5 of Main Rules.

13.5.2 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:

13.5.2.1 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 Cl.13.5.1.

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

13.5.2.3 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.

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

13.5.2.5 The exhaust duct outlets are to be positioned at least 10 m from air intake openings, openings to accommodation spaces and other enclosed areas, and at least 4 m 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.

13.6 Requirements for Machinery Spaces

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

13.6.2 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.

13.7 Requirements for Bunkering Station

13.7.1 The bunker station ventilation arrangements are to be in accordance with Pt.5, Ch.35, Cl. 13.7 of Main Rules.

13.8 Requirements for Ducts and Double Wall Pipes

13.8.1 The ventilation arrangements for fuel pipe ducting and double wall pipes are to be in accordance with Pt.5, Ch.35, Cl. 13.8 of Main Rules.

13.8.2 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.

13.8.3 The ventilation outlet from the double wall piping system is to be located in accordance with Cl.13.5.1.7.

Section 14

Electrical Installations

14.1 Goal

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

14.2 Functional Requirements

14.2.1 The functional requirements detailed in Cl.3.2 of this Guideline and Pt.5, Ch.35, Cl.14.2 of Main Rules are applicable.

14.3 General

14.3.1 Electrical installations are to be in accordance with Pt.5, Ch.35, Cl. 14.3 of Main Rules.

14.3.2 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 Cl.15.8.

Section 15

Control Monitoring and Safety Systems

15.1 Goal

15.1.1 The goal of this Section is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the fuel installations as covered in the other chapters of these guidelines.

15.2 Functional Requirements

15.2.1 The functional requirements detailed in Cl.3.2 of this Guideline and Pt.5, Ch.35, Cl.15.2 of Main Rules are applicable.

15.3 General Requirements

15.3.1 Fuel containment and fuel supply instrumentation arrangements are to be in accordance with Pt.5, Ch.35, Cl.15.3 of Main Rules.

15.3.2 Machinery spaces containing ammonia are to be fitted with remote monitoring in accordance with the requirements for **SYJ** notation of the Main Rules.

15.4 Requirements for Bunkering and Fuel Tank Monitoring

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

15.4.2 The fuel tank level and overflow control monitoring arrangements are to be in accordance with Pt.5, Ch.35, Cl.15.4 of Main Rules.

15.4.3 In addition to the indirect and closed level indicator types detailed by Pt.5, Ch.35, Cl.15.4.1.3 of Main 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.

15.5 Requirements for Bunkering Control

15.5.1 Bunkering control arrangements are to be in accordance with Pt.5, Ch.35, Cl.15.5 of Main Rules.

15.6 Requirement for Compressor Monitoring

15.6.1 Compressor monitoring arrangements are to be in accordance with Pt.5, Ch.35, Cl.15.6 of Main Rules.

15.7 Requirements for Engine Monitoring

15.7.1 Engine monitoring arrangements are to be in accordance with Pt.5, Ch.35, 15.7 of Main Rules.

15.8 Requirements for Gas Detection

15.8.1 Gas detection arrangements are to be in accordance with Pt.5, Ch.35, Cl.15.8 of Main Rules suitable for both flammability and toxicity.

15.8.2 In addition to the (ammonia) gas detection locations referenced by Pt.5, Ch.35, Cl.15.8.1 of Main 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 Cl.6.6.3

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 (Refer Cl.13.3.3).

15.8.3 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.

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

15.9 Requirements for Fire Detection

15.9.1 The required safety actions upon fire detection are given under Cl.15.12.

15.10 Requirements for Ventilation

15.10.1 Any loss of the required ventilating capacity is to give an audible and visual alarm on the navigation bridge and in a continuously manned central control station or safety centre as well as locally and with the required safety actions in accordance with Cl. 15.12.

15.11 Requirements on Safety Functions of Fuel Supply Systems

15.11.1 The fuel supply safety functions are to be in accordance with Pt.5, Ch.35, Cl.15.11 of Main Rules.

15.12 Requirements for Monitoring and Safety Functions

15.12.1 Monitoring and safety system functions are to be provided in accordance with Table 1 of Pt. 5, Ch.35, Section 15 of Main Rules, as applicable.

15.12.2 Audible and visual alarms locally and at the manned control station are to be activated in cases where

a) ammonia detected exceeds:

i. 30 ppm in fuel storage hold space
ii. 30 ppm in fuel preparation room
iii. 30 ppm at fuel preparation room ventilation exits
iv. 30 ppm at tank connection space ventilation exits
v. 30 ppm in machinery spaces containing ammonia piping , equipment or consumers
vi. 30 ppm in airlocks
vii. 150 ppm in fuel supply pipe ducting or secondary enclosure
viii. 300 ppm at vent mast exits

ix. 10 ppm at engine exhaust exits
x. 10 ppm at crankcase breather or under piston space, exits
xi. 30 ppm at ventilation inlets and openings to accommodation spaces service spaces and control stations
xii. 150 ppm at bunker station

b) Loss of oxygen level detection in fuel preparation room
c) Loss of ventilation in fuel preparation room
d) Loss ventilation in machinery space
e) Ammonia leaks to auxiliary system
f) Manual emergency shutdown is activated

15.12.3 If the concentration of ammonia exceeds 150 ppm in the fuel preparation room and tank connection space or upon activation of manual emergency shut down, the detectors are to:

i) Activate the water screens required by Cl. 5.6.2.1

ii) Activate the increased ventilation system required by Cl.13.5.2 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 Cl. 9.5.5 and Cl. 9.5.10.

15.12.4 Following are to activate automatic shutdown of fuel supply to machinery space containing consumers:

a) Ammonia exceeds 150 ppm in fuel preparation room and tank connection space.
b) Low oxygen level detection in fuel preparation room
c) Loss of ventilation in fuel preparation room
d) Ammonia exceeds 50 ppm in machinery spaces containing consumers. (Double block and bleed and Master Fuel Valves to close)
e) Ammonia exceed 300 ppm in fuel supply pipe ducting or secondary enclosure. (Double block and bleed and Master Fuel Valves to close)
f) Ammonia exceeds 50 ppm at engine exhaust exits
g) Ammonia exceeds 50 ppm at crankcase breather or under piston space, exits
h) Manual emergency shut down

15.12.5 Loss of ventilation in fuel preparation room is to activate automatic shutdown of tank valve.

15.12.6 Ammonia detection of more 300 ppm at bunker station, is to activate automatic shutdown of the bunker manifold ESD valves.

15.12.7 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.

Section 16

Manufacture, Workmanship and Testing

16.1 General

16.1.1 Materials in general are to comply with the requirements of Part 2 of Main Rules.

16.1.2 Materials for fuel containment, fuel piping and process pressure vessels are to be in accordance with Cl.7.4.

16.1.3 The manufacture, testing, inspection and documentation is to be in accordance with Pt.5, Ch.35, Section 16 and Pt.2, Ch.1 of Main Rules.

16.1.4 Arrangements are to be made for safely draining, venting and purging all ammonia vessels and piping with nitrogen before inspection and maintenance. Sampling points for measuring ammonia concentration are to be provided where necessary. The sampling system is to be of a closed loop designed to ensure that ammonia liquid and vapour are not vented to atmosphere.

16.2 Periodical Surveys

16.2.1 Annual Surveys

The surveys are to include applicable sections of Pt.1, Ch.2, (including Sec.20) of Main Rules. Additionally, annual surveys are to include:

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

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

c) Functional testing of alarms for monitoring and safety functions.

d) Functional testing of eyewash and decontamination showers.

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

f) Operational testing of associated exhaust after treatment systems.

g) Testing of portable gas detectors for ammonia.

h) Testing of fixed gas detection for ammonia.

i) Testing of gas detection:

i) where the auxiliary heat exchange circuits are likely to contain ammonia in abnormal conditions as a result of a component failure (also refer Cl. 10.3.9) .

ii) at crankcase breather, or under piston space .

iii) where the engine auxiliary systems are likely to contain ammonia in abnormal conditions as a result of a component failure (also refer Cl. 10.3.9) .

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.

Section 17

Drills and Emergency Exercises

17.1.1 Drills and emergency exercises on board are to be conducted on board at regular intervals in accordance with Pt.5, Ch.35, Section 17 of Main Rules.

Section 18

Operation

18.1 General

18.1.1 Operation and maintenance procedures are to be in accordance with Pt.5, Ch.35, Section 18 of Main Rules.

18.1.2 The operational procedures are to include the limitations for machinery space entry detailed under 5.9.2.

End of Guidelines