



GUIDELINES FOR SHIPS USING AMMONIA AS FUEL

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GUIDELINES FOR SHIPS USING AMMONIA AS FUEL

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CHAPTER 1 INTRODUCTION

1.1 Scope

The international regulations pertaining to gas or other low flashpoint fueled ships, other than those covered by the IMO International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (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 the CR regulations in the CR Guidelines for Ships Using Gases or Other Low-Flashpoint Fuels (hereinafter referred to as the Guidelines-LFFS).

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.

The Guidelines for Ships Using Ammonia as Fuel (hereinafter referred to as the Guidelines) provides guidance for the design, construction, and survey of ships utilizing anhydrous ammonia (ammonia) as fuel. The Guidelines is focused on systems and arrangements provided for the use of ammonia for propulsion and auxiliary systems.

1.2 Objective

The objective of the Guidelines is to provide classification criteria for the arrangements, construction, installation and survey of machinery, equipment and systems for ships operating with ammonia as fuel in order to minimize risks to the ship, crew and environment.

1.3 Class Notations

1.3.1 Alternative low flashpoint fueled ship – ammonia

The **LFFS** notation may be assigned where a ship is arranged to burn a low flashpoint fuel other than natural gas for propulsion or auxiliary purposes and is designed, constructed and tested in accordance with the requirements of the Guidelines-LFFS. The equivalence of the design is to be demonstrated by application of the Alternative Design criteria detailed under 2.3. The **LFFS** notation will be assigned in association with the specific low flashpoint fuel and one or more of the following additional notations (e.g., **LFFS(DFD - Ammonia)**).

Ships seeking the **LFFS** notation for ammonia as fuel are also to meet the criteria and be assigned the **CAS**, **CAU** or **CAB** notations for remote monitoring (See also 5.4.3 of the Guidelines).

Note:

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 the Guidelines, the **LFFS** notation is applied to the IGF Code ships on the basis that the process of the IMO Alternative Design process is applicable.

See also 1.1 of the Guidelines-LFFS for more information on CR notations for IGF Code ships.

1.3.2 Dual fuel diesel engine power plant

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Where a dual fuel diesel engine power plant is installed, the **LFFS(DFD - Ammonia)** notation is required and the unit is to be designed, constructed and tested in accordance with the Guidelines and the Guidelines-LFFS.

1.3.3 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 the Guidelines and Annex 2 of the Guidelines-LFFS.

1.4 Certification

The Society design review, survey, testing, and the issuance of reports or certificates constitute the certification of machinery, equipment and systems; see also the Rules for Steel Ships.

1.5 Flag Administration Approval

Where the conditions of the Guidelines are proposed to be used to comply, or support, the Guidelines-LFFS 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 the Society.

1.6 Format

The Guidelines is based on the technical requirements of the IGF Code which is contained in its entirety in the Guidelines-LFFS 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 the Guidelines is to be read as “Flag Administration” (See 1.5).

The Guidelines specifies only the unique requirements applicable to ships using ammonia as fuel. The Guidelines is always to be used in association with the IGF Code, as incorporated in the Guidelines-LFFS.

Where the Guidelines includes cross references to Parts A-1, B-1 and C-1 of the IGF Code, 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 the Guidelines.

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

CHAPTER 2 GENERAL

2.1 Application

The Guidelines is to be applied to both new construction and existing ship conversions, regardless of size, including those of less than 500 gross tonnage, utilizing ammonia as fuel.

Note:

The Guidelines has been developed for application to ships covered by the IGF Code. The Society will consider application of the Guidelines 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.

2.2 Definitions

2.2.1 For the purpose of the Guidelines, the terms used have the meanings defined in the following paragraphs. Terms not defined have the same meaning as in 2.2 of the Guidelines-LFFS.

- (a) “*Engine room*” is a machinery space containing ammonia fueled engine(s).
- (b) “*Fuel*” means anhydrous ammonia (NH₃) in its liquified or gaseous state. The terms “fuel” “ammonia” and “NH₃” used in the Guidelines refer to anhydrous ammonia.
- (c) “*Gas dispersion analysis*” is the analysis of the dispersion behavior of gases using appropriate modeling techniques such as computational fluid dynamics (CFD) analysis.
- (d) “*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.
- (e) “*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.
- (f) “*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 2.2.46 of the Guidelines-LFFS.
- (g) “*Portable tank*” means an independent tank being able to be:
 - (i) easily connected and disconnected to/from ship systems; and
 - (ii) easily removed from ship and fitted on board ship.
- (h) “*Single failure*” is where loss of intended function occurs through one fault.
- (i) “*Tank connection space*” means a space surrounding all tank connections and tank valves.
- (j) “*Toxic areas*” are areas where ammonia toxicity risk from potential leak sources exist.

2.3 Alternative Design

Equipment, components, and systems for which there are specific requirements in the Guidelines, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in the Guidelines. This, however, is subject to such alternative arrangements or standards being determined by the Society as being not less effective than the overall safety and strength requirements of the Guidelines or associated references. Where applicable, requirements may be imposed by the Society in addition to those contained in the alternative arrangements or standards so that the intent of the Guidelines is met. In all cases, the equipment, component or system is subject to design review, survey during construction, tests and trials, as applicable, by the Society for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be equivalent to that outlined in the Guidelines. See also 2.3 of the Guidelines-LFFS.

2.4 Plans and Data to Be Submitted

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

2.4.1 Ship arrangements and systems

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

- (a) Risk assessment plan and associated risk assessment report(s). (See 4.2 of the Guidelines)
- (b) General arrangement of ship
- (c) Fuel storage arrangements
- (d) Fuel supply system arrangements
- (e) Fuel bunkering station arrangements
- (f) Hazardous area classification plan
- (g) Vent mast and venting arrangements
- (h) Operations and maintenance manuals (to be submitted for reference purposes only)
- (i) Emergency response plan (to be submitted for reference purposes only)
- (j) Description of the control, monitoring and safety systems, including alarm and shutdown

2.4.2 Fuel containment system

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

- (a) General arrangement plans of the ship showing the position of the fuel containment system and details of manholes and other openings in fuel tanks

- (b) 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
- (c) 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
- (d) 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
- (e) 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
- (f) Specifications and plans of the insulation system and calculation of the heat balance
- (g) Procedures and calculations of the cooling down and loading operations, including loading limit curve
- (h) Loading and unloading systems, venting systems, and gas-freeing systems, as well as a schematic diagram of the remote-controlled valve system
- (i) Details and installation of the safety valves and relevant calculations of their relieving capacity (supported by relieving scenarios), including back pressure
- (j) 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
- (k) Schematic diagram of the ventilation system indicating the vent pipe sizes and location of the openings
- (l) Fuel tank pressure accumulation calculation
- (m) Schematic diagram of the refrigeration system together with the calculations concerning the refrigerating capacity
- (n) Details of the electrical equipment fitted in the fuel containment area and of the electrical bonding of the fuel tanks and piping
- (o) Details of testing procedures of fuel tanks and liquid and vapor systems
- (p) Diagram of inert-gas system or hold-space environmental-control system
- (q) Diagram of gas and leak detection systems
- (r) Schematic-wiring diagrams

- (s) Details of all fuel and vapor handling equipment
- (t) Details of fire extinguishing systems
- (u) Welding procedures, stress relieving and non-destructive testing plans
- (v) Construction details of submerged fuel pumps including material specifications
- (w) Operating and maintenance instruction manuals (submitted for reference purposes only)
- (x) Testing procedures during sea/gas trials (submitted for survey verification only)
- (y) Inspection/survey plan for the liquefied fuel containment system

2.4.3 Fuel bunkering system

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

- (a) General arrangement of the gas fuel bunkering system including location of the gas detectors, electrical equipment and lighting
- (b) Detailed drawings of the bunkering station, manifolds, valves, couplings and control stations
- (c) Gas fuel piping systems including details of piping and associated components, design pressures, temperatures and insulation where applicable
- (d) Material specifications for manifolds, valves and associated components
- (e) Weld procedures, stress relieving and non-destructive testing plans
- (f) Ventilation system
- (g) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- (h) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (i) Details of all electrical equipment in the bunkering and control stations
- (j) Equipotential bonding and insulating flange arrangement
- (k) Emergency shutdown (ESD) arrangements and ESD flow chart
- (l) Operating and maintenance instruction manuals (submitted for reference purposes only)
- (m) Testing procedures during sea/gas trials (submitted for survey verification only)

CHAPTER 2 GENERAL

2.4 Plans and Data to Be Submitted

2.4.4 Fuel supply system

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

- (a) General arrangement of the fuel preparation room including location of the gas and leak detectors, electrical equipment and lighting
- (b) Doors and other openings in fuel preparation rooms
- (c) Ventilation systems
- (d) Material specifications for compressors, pumps, evaporators, vaporizers, condensers, coolers, heaters, valves and associated fuel supply/return/treatment components
- (e) Fixed gas and leak detection and alarm systems, and associated shut-off and shutdown systems
- (f) Fuel piping systems including details of piping and associated components, design pressures, temperatures, insulation and fuel processing or treatment systems, where applicable
- (g) Weld procedures, stress relieving and non-destructive testing plans
- (h) Compressors
- (i) Vaporizers/heaters
- (j) Pressure vessels
- (k) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (l) Details of all electrical equipment in the fuel preparation room
- (m) Electric bonding (earthing) arrangement
- (n) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the fuel supply system
- (o) Emergency shutdown arrangements
- (p) Operating and maintenance instruction manuals (submitted for reference purposes only)
- (q) Testing procedures during sea/gas trials (submitted for survey verification only)

2.4.5 Power generation prime movers and accessories

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

- (a) General arrangement of the engine room (non-hazardous, “gas-safe”, machinery spaces) including location of the gas and leak detectors, electrical equipment and lighting
- (b) Ventilation systems
- (c) Fixed gas and leak detection and alarm systems, and associated shut-off and shutdown systems
- (d) Fuel specification(s)
- (e) Fuel piping systems including schematics for main and pilot fuel systems together with details of piping and associated components, design pressures and temperatures
- (f) Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- (g) Details of the electrical equipment
- (h) Electric bonding (earthing) arrangement
- (i) Arrangements and details of crankcase protection
- (j) FMEA to determine possible failures and their effects in the safe operation of the engine
- (k) Safety concept and/or risk analysis documentation
- (l) Arrangement of explosion protection for air inlet manifolds and for exhaust manifolds including design basis and size calculations
- (m) Emergency shutdown arrangements
- (n) List of certified safe equipment
- (o) Operating and maintenance instruction manuals (submitted for reference purposes only)
- (p) Testing procedures during sea/gas trials (submitted for survey verification only)
- (q) Engine specific time referenced by 10.3.1.7 of the Guidelines-LFFS, 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.

CHAPTER 3 GOAL AND FUNCTIONAL REQUIREMENTS

3.1 Goal

The goal of this Chapter 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.

3.2 Functional Requirements

The functional requirements of 3.2 of the Guidelines-LFFS are applicable and are included below with additional functional requirements that are to be considered, but not limited to:

3.2.1 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.

3.2.2 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.

3.2.3 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.

3.2.4 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.

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

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

3.2.7 System components shall be protected against external damages.

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

3.2.9 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.

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

3.2.11 *Machinery, systems and components shall 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 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.*

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

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

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

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

3.2.17 *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.*

3.2.18 *A single failure in a technical system or component shall not 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 onboard.*

Note:

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

CHAPTER 4 GENERAL PROVISIONS

4.1 Goal

The goal of this Chapter 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.

4.2 Risk Assessment

4.2.1 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.

4.2.2 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 to be documented by report and submitted for review.

Note:

See IACS Recommendation No.146 Risk Assessment as Required by the IGF Code.

4.2.3 The risk assessment is to specifically consider, but not limited to, the items referenced by the Guidelines and the Guidelines-LFFS:

- (a) Required number of compressed air safety equipment sets – see 5.11.4 of the Guidelines
- (b) Duration of the emergency escape breathing devices (EEBDs) – see 5.11.7 of the Guidelines
- (c) Number of, persons and location of, machinery space emergency escape equipment – see 5.11.7 of the Guidelines
- (d) The toxic areas identified by 12.6 of the Guidelines, including arrangements and access for Life-Saving Appliances(LSA) equipment, muster stations and escape routes. For those ships 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 self-contained air support in accordance with Chapter IV, 4.8 of the Life-Saving Appliances Code
- (e) Arrangements for GVU or GVT spaces/enclosures – see 9.5.8 of the Guidelines
- (f) Capacity of drip trays – see 5.10.5 of the Guidelines-LFFS.
- (g) Arrangements of airlocks – see 5.12.3 of the Guidelines-LFFS.
- (h) Evaluation of the fuel containment system – see 6.4.1.1 of the Guidelines-LFFS.

- (i) Arrangements of closed or semi-enclosed bunker stations – see 8.3.1.1 and 13.7 of the Guidelines-LFFS.
- (j) 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 the Guidelines and 15.8.1.10 of the Guidelines-LFFS.
- (k) 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 the Guidelines

4.2.4 The risk assessment plan developed and submitted to the Society for review should contain:

- (a) Description of proposed Function
- (b) Quantitative or qualitative risk assessment method(s) to be used and description if using a nonstandard method
- (c) Scope and objectives of the assessment
- (d) Subject matter experts / participants / risk analysts, including their background and area of expertise
- (e) Proposed risk acceptance criteria or risk matrix
- (f) Risk control and management measures

4.3 Limitation of Explosion Consequences

4.3.1 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, 4.3 of the Guidelines-LFFS is applicable.

Note 1:

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

CHAPTER 5 SHIP DESIGN AND ARRANGEMENT

5.1 Goal

The goal of this Chapter 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.

5.2 Functional Requirements

The functional requirements of 3.2 of the Guidelines and 5.2 of the Guidelines-LFFS are applicable.

5.3 General Provisions

The fuel containment protection requirements of 5.3 of the Guidelines-LFFS are applicable.

5.4 Machinery Space (Engine Room) Arrangements

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 spaces concept of 5.4.1.1 of the Guidelines-LFFS is to be applied to all machinery spaces containing ammonia consumers.

Note:

The IGF Code “ESD machinery space” concept is not to be applied for ammonia as fuel installations. Accordingly, all the Guidelines-LFFS references from the 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 gas and liquid tight enclosures in accordance with 9.6 of the Guidelines-LFFS.

5.4.3 Machinery spaces containing ammonia as fuel consumers are to be arranged for remote monitoring in accordance with the **CAS**, **CAU** or **CAB** requirements, of the Rules for Steel Ships.

5.5 Location and Protection of Fuel Piping

5.5.1 Fuel pipes are to be located and protected in accordance with 5.7.1 to 5.7.3 of the Guidelines-LFFS.

5.6 Fuel Preparation Room

5.6.1 General

- (a) 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.

- (b) Fuel preparation rooms are to be separated by gastight bulkheads and decks from other spaces.
- (c) Fuel preparation rooms are to be located outside other machinery spaces of category A.
- (d) When located on deck, fuel preparation rooms are to be protected against mechanical damage where ship cargo handling operations increase the risk of mechanical impact damage.
- (e) 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.
- (f) 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.
- (g) Where ammonia is heated or cooled, the heating or cooling medium is to be utilized in an independent, closed system.

5.6.2 Access, openings and water screens

- (a) Unless permitted by SOLAS Chapter II-2 Regulation 13.2, a minimum of 2 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 Chapter 15 of the Guidelines. 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.
- (b) Duct, pipe and cable penetrations of bulkheads and decks of the fuel preparation room are to be made gastight.

5.7 Bilge Systems

5.7.1 Bilge system design and arrangements are to be in accordance with 5.9 of the Guidelines-LFFS.

5.7.2 Drainage of fuel preparation room

- (a) The fuel preparation room is to be provided with an independent bilge system.
- (b) The deck plating is to be arranged to facilitate easy cleaning and drying. No other plating above the deck is to be provided.
- (c) 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.

- (d) 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 should:
 - (i) not be stowed adjacent to oil fuel tanks;
 - (ii) have separate piping systems; and
 - (iii) have tank vent systems separate from tanks containing nontoxic products.

Note:

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

5.8 Drip Trays

5.8.1 Drip tray design and arrangements, as applicable to ammonia, are to be in accordance with 5.10 of the Guidelines-LFFS.

5.9 Arrangement of Entrances and Other Openings in Enclosed Spaces

5.9.1 Arrangements of entrances and other opening in enclosed spaces are to be in accordance with 5.11.1 through 5.11.3 and 5.11.5 of the Guidelines-LFFS.

5.10 Airlocks

5.10.1 Airlocks are to be in accordance with 5.12 of the Guidelines-LFFS.

5.11 Personnel Safety and Personal Protective Equipment (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 Chapter is to be kept in suitable, clearly marked lockers located in readily accessible places.

5.11.3 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.

5.11.4 A minimum of 3 complete sets of safety equipment are to be provided in addition to the required firefighter's outfits. The risk assessment required by 4.2 of the Guidelines 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.

5.11.5 Each complete set of safety equipment is to consist of:

- (a) 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 liters of free air. Each set is to be compatible with the required firefighter's outfits.

- (b) protective gas tight clothing (without any exposed skin), boots and gloves to a recognized standard.
- (c) steel-cored rescue line with belt.
- (d) explosion-proof lamp.

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

- (a) at least one fully charged spare air bottle for each breathing apparatus required by 5.11.4 of the Guidelines,
- (b) an air compressor of adequate capacity capable of continuous operation, suitable for the supply of high-pressure air of breathable quality and
- (c) a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by 5.11.4 of the Guidelines.

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:

- (a) filter type respiratory protection is not acceptable.
- (b) 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 4.2 of the Guidelines is to specifically consider the need for additional duration.

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

Adequate emergency escape equipment for respiratory and eye protection is to be located at sufficient locations within the space to support personnel escape in the event of a fuel leak to the space. The risk assessment required by 4.2 of the Guidelines 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:

- (a) 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.
- (b) 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 2 eyewash stations and safety showers, one for each side.

CHAPTER 5 SHIP DESIGN AND ARRANGEMENT

5.11 Personnel Safety and Personal Protective Equipment (PPE)

- (c) 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).
- (d) 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 2 sets of portable ammonia gas detectors that meet an acceptable national or international standard.

CHAPTER 6 FUEL CONTAINMENT SYSTEM

6.1 Goal

The goal of this Chapter 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.

6.2 Functional Requirements

The functional requirements detailed in 3.2 of the Guidelines and 6.2 of the Guidelines-LFFS are applicable.

6.3 General

6.3.1 The general fuel containment requirements of 6.3.2 through 6.3.12 of the Guidelines-LFFS, 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 the Guidelines-LFFS and the Guidelines 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 6.4.15 of the Guidelines-LFFS 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

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 as follows are to be taken, as appropriate.

- (a) Where carbon manganese steel is used, cargo tanks, process pressure vessels and cargo piping shall be made of fine grained steel with a specified minimum yield strength not exceeding 355 N/mm^2 and with an actual yield strength not exceeding 440 N/mm^2 . One of the following constructional or operational measures shall also be taken
 - (i) lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 shall be used; or
 - (ii) cargo tanks, etc., shall be post weld stress relief heat treated; or

6.4 Fuel Containment

- (iii) carriage temperature shall be maintained preferably at a temperature close to the product's boiling point of -33°C but in no case at a temperature above -20°C ; or
 - (iv) the ammonia shall contain not less than 0.1% w/w water, and the master shall be provided with documentation confirming this.
- (b) If carbon manganese steels with higher yield properties are used other than those specified in 6.4.4 (a), the completed cargo tanks, piping, etc., shall be given a post weld stress relief heat treatment.
 - (c) Process pressure vessels and piping of the condensate part of the refrigeration system shall be given a post-weld stress relief heat treatment when made of materials made of carbon manganese steel or nickel steel.
 - (d) The tensile and yield properties of the welding consumables shall exceed those of the tank or piping material by the smallest practical amount.
 - (e) Nickel steel containing more than 5% nickel and carbon manganese steel not complying with the requirements of 6.4.4 (a) and (b) are particularly susceptible to ammonia stress corrosion cracking and shall not be used for containment and piping systems for the carriage of this product.
 - (f) Nickel steel containing not more than 5% nickel may be used provided the carriage temperature complies with the requirements specified in 6.4.4 (a) (iii).
 - (g) In order to minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 ppm (w/w). This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature T in the table below:

T($^{\circ}\text{C}$)	O ₂ (% v/v)
- 30 and below	0.90
- 20	0.50
- 10	0.28
0	0.16
10	0.10
20	0.05
30	0.03

6.4.5 Materials of construction such as aluminum and austenitic stainless steel may be applied in ammonia service as permitted by Chapter 7 of the Guidelines-LFFS. Subject to review and agreement of the Society, 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 6.5 of the Guidelines-LFFS.

6.6 Pressure Relief Systems

6.6.1 Pressure relief valves and systems in accordance with 6.7.1 to 6.7.3 of the Guidelines-LFFS are to be provided. However, fuel tank PRV (Pressure Relief Valve) vent exits are to be arranged at a distance at least equal to breadth of ship 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 ships 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.

6.6.2 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.

6.6.3 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 Chapter 15 of the Guidelines.

6.6.4 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 the Guidelines.

6.7 Filling and Loading Limit for Fuel Tanks

6.7.1 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.

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 6.8.1 of the Guidelines-LFFS. A loading limit curve for the actual fuel loading temperatures is to be prepared.

6.8 Maintaining 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 6.9.1 and 6.9.4 of the Guidelines-LFFS.

The 15 day criteria for maintaining tank pressure below the set pressure of the relief valve detailed under 6.9.1 of the Guidelines-LFFS, 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 6.9.2 and 6.9.6 of the Guidelines-LFFS.

6.9 Atmospheric Control Within the Fuel Containment

6.9.1 Provision to enable each fuel tank to be gas-freed are to be provided in accordance with 6.10 of the Guidelines-LFFS.

6.10 Atmospheric Control Within Fuel Storage Hold Spaces

6.10.1 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 6.11 of the Guidelines-LFFS.

6.10.2 Atmospheric control arrangements for fuel storage hold spaces surrounding Type C independent tanks are to be in accordance with 6.12 of the Guidelines-LFFS.

6.11 Inert Gas Arrangements

6.11.1 Inert gas arrangements are to be in accordance with 6.13 of the Guidelines-LFFS.

6.11.2 Where inert gas is produced on board, the production and storage arrangements are to be in accordance with 6.14 of the Guidelines-LFFS.

6.12 Reliquefaction and Refrigeration Systems

6.12.1 The dedicated fuel reliquefaction and refrigeration systems are to be designed in accordance with 6.9.3 and Annex 2 of the Guidelines-LFFS.

6.12.2 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.

CHAPTER 7 MATERIAL AND GENERAL PIPE DESIGN

7.1 Goal

The goal of this Chapter 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.

7.2 Functional Requirements

The functional requirements detailed in 3.2 of the Guidelines and 7.2 of the Guidelines-LFFS are applicable.

7.3. General Pipe Design

7.3.1 Fuel pipe design and arrangements are to be in accordance with 7.3 of the Guidelines-LFFS.

7.4. Materials

7.4.1 Materials in general are to comply with the requirements of the Materials(Part XI) and Welding(Part XII) of the Rules for Steel Ships.

7.4.2 Materials for fuel containment, fuel piping, process pressure vessels are to be in accordance with 7.4 of the Guidelines-LFFS and where applicable, 7.4.4 of the Guidelines.

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 6.4.4(a) to (g) of the Guidelines 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 Chapter 7 of the Guidelines-LFFS. Subject to review and agreement of CR, 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, 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:

- (a) Mercury, cadmium, copper, zinc or alloys of these materials

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 the Society, 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.

CHAPTER 8 BUNKERING

8.1 Goal

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

8.2 Functional Requirements

8.2.1 The functional requirements detailed in 3.2 of the Guidelines and 8.2 of the Guidelines-LFFS are applicable.

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

8.3 General

See the requirements under 5.11 of the Guidelines for ammonia bunkering PPE requirements.

8.4 Bunkering Station

Fuel bunkering station arrangements are to be in accordance with 8.3 of the Guidelines-LFFS.

8.5 Bunkering Manifold

Fuel bunkering manifold arrangements are to be in accordance with 8.4 of the Guidelines-LFFS.

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

8.6 Bunkering System

Fuel bunkering system arrangements are to be in accordance with 8.5 of the Guidelines-LFFS.

8.7 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 15.8 of the Guidelines.

Monitoring and safety system functions are to be provided in accordance with Chapter 15 of the Guidelines.

CHAPTER 9 FUEL SUPPLY TO CONSUMERS

9.1 Goal

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

9.2 Functional Requirements

9.2.1 The functional requirements detailed in 3.2 of the Guidelines and 9.2 of the Guidelines-LFFS 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

9.3.1 The requirements specified in this Chapter 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 ship type to ship 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 6.12 of the Guidelines.

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 a 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 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.

9.5 Safety Functions of the Fuel Supply System

9.5.1 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.

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.

CHAPTER 9 FUEL SUPPLY TO CONSUMERS

9.5 Safety Functions of the Fuel Supply System

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 Chapter 15 of the Guidelines is activated.

Note:

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 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.

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 Chapter 15 of the Guidelines.

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 9.5.3 of the Guidelines.

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

- (a) from safe location on the primary escape route from the engine room
- (b) secondary escape route from the engine room
- (c) at a location outside the engine room(s)
- (d) outside the fuel preparation room
- (e) at the engine control room and
- (f) 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 outlined in (a) or (b) below, so that when the safety system required in Chapter 15 of the Guidelines is activated this will cause the shutoff valves that are in series to close automatically and the bleed valve to open automatically. Also:

- (a) the 2 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 2 valves in series; or
- (b) 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 2 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 GVU or GVT, may be located in a dedicated space or double barrier enclosure. In such cases they are to be arranged in accordance with 10.3.1.15 of the Guidelines-LFFS and are to be considered by the risk assessment required by 4.2 of the Guidelines.

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.

Note:

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

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 (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.

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 9.5 of the Guidelines-LFFS.

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 9.6 of the Guidelines-LFFS.

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 9.8 of the Guidelines-LFFS.

9.9 Compressors and Pumps

9.9.1 Compressors and pumps are to be in accordance with 9.9 and 9.11 of the Guidelines-LFFS.

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 9.10 of the Guidelines-LFFS.

9.11 Ancillary Systems

9.11.1 The design of the fuel supply ancillary systems is to be in accordance with 9.12 of the Guidelines-LFFS.

CHAPTER 10 POWER GENERATION INCLUDING PROPULSION AND OTHER ENERGY CONVERTERS

10.1 Goal

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

10.2 Functional Requirements

10.2.1 The functional requirements detailed in 3.2 of the Guidelines and 10.2 of the Guidelines-LFFS are applicable.

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

10.3 General

10.3.1 Internal combustion engines intended to burn ammonia as fuel are to be designed, tested and certified in accordance with Chapter 10 of the Guidelines-LFFS, as applicable.

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

10.3.2 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.

10.3.3 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.

10.3.4 Internal combustion engines, and as applicable, associated exhaust aftertreatment systems, are to be designed such that ammonia (NH₃) content in the exhaust gas does not exceed 10 ppm.

Where selective catalytic reduction (SCR) exhaust aftertreatment equipment is installed to meet NO_x emissions limits, or the above NH₃ limit, with or without dedicated NH₃ control catalysts, the arrangements are to be in accordance with the CR Guidelines for Selective Catalytic Reduction Systems.

Monitoring of exhaust(s) is to be in accordance with Chapter 15 of the Guidelines.

10.3.5 The crankcase breather, or under piston space, gases from those internal combustion engines likely to contain NH₃, as determined by the engine safety concept, are to be designed to achieve a maximum of 10 ppm NH₃ at the vent exit.

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

10.3.6 The design of internal combustion engines is to be in accordance with 10.1.1, 10.3.1.1 through 10.3.1.3 and 10.3.1.5 through 10.3.1.7 of the Guidelines-LFFS, as applicable.

10.4 Dual Fuel Engines

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 (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.

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 3.2 of Part VII of the Rules for Steel Ships, however, consideration may be given to the use of alternative performance criteria such as ISO 8528 where appropriately matched with the ship power management system.

10.3.9 Engine air inlet manifolds and crankcases are to be arranged in accordance with 10.3.1.12 and 10.3.1.13 of the Guidelines-LFFS.

10.3.10 A 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..

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 10.3.2 of the Guidelines-LFFS.

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 10.3.2 and 10.3.3 of the Guidelines.

CHAPTER 11 FIRE SAFETY

11.1 Goal

The goal of this Chapter 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.

11.2 Functional Requirements

11.2.1 The functional requirements detailed in 3.2 of the Guidelines and 11.2 of the Guidelines-LFFS are applicable.

11.3 General

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

11.3.2 The fire protection requirements of 11.3.1 through 11.3.6 of the Guidelines-LFFS are applicable.

11.4 Fire Main

11.4.1 The fire main is to be arranged in accordance with 11.4 of the Guidelines-LFFS.

11.5 Water Spray System

11.5.1 The water spray system is to be arranged in accordance with 11.5 of the Guidelines-LFFS.

11.5.2 In addition to the water spray system providing coverage for the fuel tanks, and the additional locations required by 11.5.2 of the Guidelines-LFFS, 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.

11.5.3 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 the Guidelines. With respect to application of 11.5.2 of the Guidelines-LFFS, the system is to be provided regardless of the distance of the bunker station from the fuel tank.

11.6 Bunker Station Fire-Extinguishing System

11.6.1 The bunker station fire-extinguishing system is to be arranged in accordance with 11.6 of the Guidelines-LFFS.

11.7 Fire Detection and Alarm System

9.7.1 The fire detection and alarm systems are to be arranged in accordance with 11.7 of the Guidelines-LFFS.

11.8 Fire Extinguishing of Engine Room and Fuel Preparation Room

11.8.1 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.

CHAPTER 12 EXPLOSION PREVENTION, AREA CLASSIFICATION AND TOXIC AREAS

12.1 Goal

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

12.2 Functional Requirements

12.2.1 The functional requirements detailed in 3.2 of the Guidelines and 12.2 of the Guidelines-LFFS 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.

12.3 General

12.3.1 The requirements of 12.3.1 through 12.3.2 of the Guidelines-LFFS are applicable.

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

12.4 Area Classification

12.4.1 The hazardous area classification requirements of 12.4 of the Guidelines-LFFS are applicable.

12.5 Hazardous Area Zones

12.5.1 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.

12.5.2 Hazardous area zone 1

This zone includes, but is not limited to:

- (a) 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.

12.6 Toxic Areas

- (b) fuel preparation rooms
- (c) 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
- (d) enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, enclosed bunkering stations, GVV / GVT spaces
- (e) 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
- (f) other enclosed spaces where leakage of ammonia may occur

12.5.3 Hazardous area zone 2

This zone includes, but is not limited to:

- (a) areas 4 m beyond the cylinder and 4 m beyond the sphere defined in 12.5.2.(c) of the Guidelines
- (b) areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1
- (c) space containing bolted hatch to tank connection space
- (d) airlocks

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 the Guidelines 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.

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:

- (a) 25 m from the vent mast

- (b) 10 m from
- (i) 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.

- (ii) areas on the open deck within spillage coamings surrounding bunker manifold valves;
- (iii) 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 4.2 of the Guidelines. 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.

CHAPTER 13 VENTILATION

13.1 Goal

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

13.2 Functional Requirements

13.2.1 The functional requirements detailed in 3.2 of the Guidelines and 13.2 of the Guidelines-LFFS are applicable.

13.3 General

13.3.1 Ventilation design and arrangements are to be in accordance with 13.3 of the Guidelines-LFFS.

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

Note:

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.

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 (f) of the Guidelines, 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 Chapter 15, Table 15-1 of the Guidelines.

13.3.4 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.

13.4 Tank Connection Space

13.4.1 The tank connection space arrangements are to be in accordance with 13.4 of the Guidelines-LFFS.

13.5 Fuel Preparation Room

13.5.1 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:

- (a) The ventilation system is to be independent of other shipboard ventilation systems.
- (b) 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.

- (c) The ventilation system is to be designed for continuous operation and alarmed at a continuously manned central control station upon failure.
- (d) 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.
- (e) 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.
- (f) 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.
- (g) 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.
- (h) Ventilation systems for fuel preparation rooms, are to be in operation when fuel supply equipment or fuel management equipment are in operation.
- (i) Design of ventilation fans serving the fuel preparation room are also to be of the non-sparking type.

13.5.2 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:

- (a) 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 the Guidelines.
- (b) The gas evacuation system is to be arranged to automatically start when the concentration of ammonia in the space exceeds 150 ppm.
- (c) 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.
- (d) The gas evacuation system controls are to be positioned outside the space.
- (e) 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, except as otherwise permitted for the normal ventilation outlet.

13.6 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 Bunkering Station

13.7.1 The bunker station ventilation arrangements are to be in accordance with 13.7 of the Guidelines-LFFS.

13.8 Ducts and Double Pipes

13.8.1 The ventilation arrangements for fuel pipe ducting and double wall pipes are to be in accordance with 13.8 of the Guidelines-LFFS.

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.

13.8.2 The ventilation outlet from the double wall piping system is to be located in accordance with 13.5.1(g) of the Guidelines.

CHAPTER 14 ELECTRICAL INSTALLATIONS

14.1 Goal

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

14.2 Functional Requirements

14.2.1 The functional requirements detailed in 3.2 of the Guidelines and 14.2 of the Guidelines-LFFS are applicable.

14.3 General

14.3.1 Electrical installations are to be in accordance with 14.3 of the Guidelines-LFFS.

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 15.8 of the Guidelines.

CHAPTER 15 CONTROL, MONITORING AND SAFETY SYSTEMS

15.1 Goal

The goal of this Chapter 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 Chapters of the Guidelines.

15.2 Functional Requirements

15.2.1 The functional requirements detailed in 3.2 of the Guidelines and 15.2 of the Guidelines-LFFS are applicable.

15.3 General

15.3.1 Fuel containment and fuel supply instrumentation arrangements are to be in accordance with 15.3 of the Guidelines-LFFS.

15.3.2 Machinery spaces containing ammonia are to be fitted with automatic or remote control and monitoring in accordance with the **CAS**, **CAU** or **CAB** requirements of the Rules for Steel Ships.

15.4 Bunkering and Liquefied 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 15.4 of the Guidelines-LFFS.

15.4.3 In addition to the indirect and closed level indicator types detailed by 15.4.1.3 of the Guidelines-LFFS, 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 Bunkering Control

15.5.1 Bunkering control arrangements are to be in accordance with 15.5 of the Guidelines-LFFS.

15.6 Compressor Monitoring

15.6.1 Compressor monitoring arrangements are to be in accordance with 15.6 of the Guidelines-LFFS.

15.7 Engine Monitoring

15.7.1 Engine monitoring arrangements are to be in accordance with 15.7 of the Guidelines-LFFS.

15.8 Gas Detection Systems

15.8.1 Gas detection arrangements are to be in accordance with 15.8 of the Guidelines-LFFS suitable for both flammability and toxicity.

15.8.2 In addition to the gas (ammonia) detection locations referenced by 15.8.1 of the Guidelines-LFFS, the ammonia vapor detection and alarm system is to be provided to warn of the release of ammonia at the following locations:

- (a) Fuel storage hold spaces
- (b) The vent mast identified under 6.6.3 of the Guidelines
- (c) The ventilation exhaust ducts from fuel preparation and tank connection spaces
- (c) Internal combustion engine exhaust system exits for exhaust or end of stack monitoring
- (e) Internal combustion engine crankcase breather, or under piston space, vent exits;
- (f) All air intakes and other openings into the accommodation spaces, service spaces and control stations, which are normally manned – see 13.3.3 of the Guidelines.

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.

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

15.9 Fire Detection

15.9.1 The required safety actions upon fire detection are given under 15.12 of the Guidelines.

15.10 Ventilation

15.10.1 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 15.12 of the Guidelines.

15.11 Safety Functions of Fuel Supply Systems

15.11.1 The fuel supply safety functions are to be in accordance with 15.11 of the Guidelines-LFFS.

15.12 Monitoring and Safety Functions

15.12.1 Monitoring and safety system functions are to be provided in accordance with Table 15-1 to 15-9 of the Guidelines-LFFS, as applicable, and Table 15-1 of the Guidelines.

15.12.2 If the concentration of ammonia exceeds the indicated levels of Table 15-1 of the Guidelines, the detectors are to activate audible and visual alarms locally and at the manned control station.

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

- (a) Activate the water screens required by 5.6.2 of the Guidelines
- (b) Activate the increased ventilation system required by 13.5.2 of the Guidelines and
- (c) 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 the Guidelines.

**TABLE 15-1
 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				
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

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 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
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				
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 ⁽³⁾				
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
Notes:					
(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 the Guidelines.					
(4) To close the self-closing devices referenced by 13.3.3 of the Guidelines.					

CHAPTER 16 SURVEY, MANUFACTURE, WORKMANSHIP AND TESTING

16.1 General

16.1.1 Materials in general are to comply with the requirements of the Materials (Part XI) and Welding (Part XII) of the Rules for Steel Ships .

16.1.2 Materials for fuel containment, fuel piping, process pressure vessels are to be in accordance with 7.4 of the Guidelines.

16.1.3 The manufacture, testing, inspection and documentation is to be in accordance with Chapter 16 of the Guidelines-LFFS.

16.1.4 Survey during construction:

For survey during construction of various equipment and systems, the survey is to include applicable of Part I of the Rules for Steel Ships.

16.1.5 Survey after construction:

(a) Annual survey

For annual survey, the survey is to include applicable of the Part I of the Rules for Steel Ships.

Additionally, annual survey is to include:

- (i) Functional testing of water screens above access doors for fuel preparation room.
- (ii) Functional testing of gas evacuation system for fuel preparation room.
- (iii) Functional testing of alarms for monitoring and safety functions, see Table 15-1.
- (iv) Functional testing of eyewash and decontamination showers.
- (v) Operational testing of fuel treatment or vent control systems utilizing water scrubbing or treatment systems.
- (vi) Operational testing of associated exhaust aftertreatment systems.
- (vii) Testing of portable gas detectors for ammonia.
- (viii) Testing of fixed gas detection for ammonia.
- (ix) Testing of gas detection:
 - (1) 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).
 - (2) at crankcase breather, or under piston space.
 - (3) 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).
- (x) Examination of toxic areas and ventilation intakes including gas detection system for ammonia.
- (xi) Examination of all other personnel safety and PPE specific to ammonia.

(b) Intermediate surveys

For intermediate surveys, the survey is to include applicable of Part I of the Rules for Steel Ships.

(c) Special surveys

For special surveys, the survey is to include applicable of Part I of the Rules for Steel Ships.

CHAPTER 17 DRILLS AND EMERGENCY EXERCISES

17.1 General

17.1.1 Drills and emergency exercises are to be conducted on board at regular intervals in accordance with Chapter 17 of the Guidelines-LFFS.

CHAPTER 18 OPERATION

18.1 General

18.1.1 Operation and maintenance procedures are to be in accordance with Chapter 18 of the Guidelines-LFFS.

18.1.2 The operational procedures are to include the limitations for machinery space entry detailed under 5.11.7 of the Guidelines.