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Guidelines for Ships Using Ammonia as Fuels

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CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This Part applies to ships using ammonia as fuel in accordance with **Ch 1, 101. 18** of the **Rules for the Classification of Ships Using Low-flashpoint Fuels**(hereafter referred to as "**the Rules**").
2. The requirements of this Guidelines are prescribed in addition to the requirements in the Rules. Except where specially required in this Guidelines, the relevant requirements in **the Rules** are to be applied.

102. Definition

The definitions of terms not specified in the followings are to be as specified in **the Rules**.

1. **Fuel** means ammonia either in the gaseous state or in the liquid state.
2. **Bunkering** means the transfer of ammonia fuel from land-based or floating facilities into ship's permanent tanks.
3. **Toxic zone** means an area or space in which ammonia exists or is likely to exist in concentrations hazardous to human health.
4. **Non-toxic zone** means an area or space other than toxic zone.
5. **Permissible Exposure Limit(PEL)** means the concentration of ammonia gas in the air that does not affect human health, and the permissible exposure limit in this Guidelines is not more than 25 ppm which is the TWA value of NIOSH.
6. **Upper concentration limit of release** means the maximum concentration of ammonia gas in the air that is to be limited on board, except in case of emergnecy, resulting severe irreversible health effects and impairment of the ability to escape from the exposure environment. Upper concentration limit of release in this Guidelines 300 ppm which is the Immediately Dangerous to Life or Health(IDLH) value of NIOSH.
7. **Source of Release** means a point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive or toxic atmosphere could be formed.
8. **Ammonia Treatment Systems** in this Guidelines means systems that reduce or remove either liquid or gaseous ammonia to prevent it from being released into the surroundings.

103. General

1. This Guidelines contains functional requirements for all appliances and arrangements related to the usage of fuel typically having the characteristics of **Table 1, Table 2, Table 3 and Table 4**.
2. Appliances and arrangements of ammonia fuel systems may deviate from those set out in this Guidelines, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety to the relevant sections.
3. **Ch 1, 103. 3** of **the Rules** is to be applied.

Table 1 Properties comparison of ammonia and LNG

properties	LNG	Ammonia	related characteristics
Flammable limits in air by volume (%)	5 ~ 15	15~28	· unfavorable to ignite due to formation of flammable atmosphere at higher concentrations
Autoignition temperature (℃)	595	651	· no additional consideration for exhaust gas temperature due to high auto-ignition temperature
Minimum ignition energy (mJ)	0.28	680	· difficult to ignite due to significantly high minimum ignition energy compared with methane
Boiling point at 1 bar absolute (℃)	-161	-33	· Difficult to visually check for leaks
Vapour pressure at 45 ℃ (MPa)	-	1.8	· liquefaction by pressurizing at atmospheric temperature
Critical temperature (℃)	-82.95	132.5	· stored at atmospheric temperature under pressure

Table 2 Symptoms according to ammonia concentration

concentration (ppm*)	Symptoms
5	Pungent odor
6-20	Eye irritation and nose irritation
40-200	Headache, nausea and loss of appetite
400	Severe throat irritation
700	Loss of sight
1700	Coughing, serious lung damage, shortness of breath
2,500-4,500	Immediately Dangerous to Life or Health
5,000	Death due to respiratory arrest
note) * 1 ppm = 0.0001%	

Table 3 Acute exposure guidelines levels (US-EPA)

Exposure time	10 min	30 min	60 min	4 hour	8 hour
AEGL-1	30 ppm	30 ppm	30 ppm	30 ppm	30 ppm
AEGL-2	220 ppm	220 ppm	160 ppm	110 ppm	110 ppm
AEGL-3	2,700 ppm	1,600 ppm	1,100 ppm	550 ppm	390 ppm
* AEGL-1 : The general population may experience irritation but reviersible upon cessation of exposure * AEGL-2 : The effects may be irreversible or lead to long lasting adverse health effects * AEGL-3 : The general population may experience life-threatening health effect for death					

Table 4 Exposure limit at workplace(NIOSH)

	Concentration
TWA	25 ppm
STEL	35 ppm
IDLH	300 ppm
* TWA : Time-weighted average - a measurement of average exposure over a certain time period, given as 8 hours * STEL : Short-term exposure limit - a measurement of exposure over a short period, given as 15 min. * IDLH : Maximum concentration value resulting severe irreversible health effects and impairment of the ability to escape from the exposure environment.	

CHAPTER 2 GOAL AND FUNCTIONAL REQUIREMENTS

Section 1 Goal

The goal of this 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.

Section 2 Functional Requirements

In addition to **Ch 2, Sec 2** of **the Rules**, the followings are to be applied;.

1. Ammonia gas is not to be released at concentrations that pose significant hazard to health at the source of leakage of ammonia fuel,
2. In applying **Ch 2, 201. 4** of **the Rules**, special consideration should be given to the effect of fuel toxicity to the personnel on board.
3. In applying **Ch 2, 201. 9** of **the Rules**, a direct release of fuel into the atmosphere is not permitted except emergency case in which uncontrollable release occurs due to fire or collision. ⚓

CHAPTER 3 GENERAL REQUIREMENTS

Section 1 Goal

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

Section 2 Risk Assessment

201. Risk assessment

1. A risk assessment is to be conducted to ensure that risks arising from use of ammonia fuel affecting the person on board, the environment and the ship are addressed. Consideration is to be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.
2. The risk assessment is to address the possible leakage of the fuel and the consequences thereof. In particular, consideration is to be given to the hazards associated toxicity and corrosiveness of fuel.
3. Risk assessment is to be conducted in accordance with **Annex 3** of **the Rules**. However, since **Annex 3, Sec.2** of **the Rules** deals with the properties and risk of LNG, ammonia typically having the characteristics of **Ch 1, Table 1, Table 2, Table 3,** and **Table 4** are to be applied instead.
4. In risk assessment, in addition to **Ch 3, 201.** of **the Rules**, the followings are to be as a minimum considered, but not limited to:
   (1) Properties and related risks of ammonia according to **Ch 1, Table 1, Table 2, Table 3,** and **Table 4** considering the effect on the personnel on board
   (2) Drip tray according to **Ch 5, Sec 10, 1**
   (3) Dispersion/ventilation characteristics of leaked ammonia according to **Ch 6, Sec 3, 2**

Section 3 Limitation of Explosion Consequences

301. Limitation of explosion consequences

An explosion in any space containing any potential sources of release and potential ignition sources is to limited in accordance with **Ch 3, 301.** of **the Rules.**

Section 4 Prevention of Exposure to Toxicity

401. General

1. The permissible concentration limit of ammonia is to be determined for the safety measures to protect personnel from harmful concentration. In this guidelines, the concentration limit of ammonia is set as the permissible exposure limit and upper concentration limit of release, respectively by referring to the TWA and IDLH.
2. Considering the crew may be exposed daily for working time during the ship's operation, 25 ppm, a TWA in a similar working environment was set as the permissible exposure limit on the ship.
3. The upper concentration limit of release is the concentration of ammonia that lead to irreversible long lasting adverse health effects even with a single exposure in a short time and is not to be not exposed to the crew. The upper concentration limit of release is set at 300 ppm, which is the concentration of IDHL.

402. Prevention of exposure to toxicity

The consequency of ammonia gas toxicity from potential sources of release is to be limited to:

1. Personnel is not to be exposed to harmful gas concentrations.
2. The concentration of gases released into the atmosphere is to be limited so as not to present the a significant health hazard.
3. Personnel access to the toxic zone is to be restricted.
4. Released ammonia gas is not to spread to the non-toxic zone. ⚓

CHAPTER 4 CLASSIFICATION AND SURVEYS

Section 1 General

101. General

1. The classification and surveys of ships intended to be classed with the Society or classed with the Society are to be in accordance with the requirements specified in this Chapter.
2. In the case of items not specified in this Chapter, the requirements specified in **Pt 1** of **Rules for the classification of steel ships** are to be applied.

Section 2 Classification

201. Class notation

Ships satisfying the requirements of this Part may be given a notation LFFS (DF-Ammonia, SF-Ammonia) as additional special feature notations.

202. Maintenance of classification

1. Ships classed with the Society are to be subjected to the surveys to maintain the classification and are to be maintained in good condition in accordance with the requirements specified in this Chapter.
2. Plans and particulars of any proposed alterations to the approved scantlings or arrangements of hull, machinery or equipment are to be submitted for approval by the Society before the work is commenced and such alterations are to be Surveyed by the Society.

203. Classification Survey during Construction.

1. General

At the Classification Survey during Construction, the hull, machinery and equipment are to be examined in detail in order to ascertain that they meet the relevant requirements of this Guidelines.

2. Plan and Documents

For a ship in which ammonia-fuelled engine installations are installed, plans and documents, specified below **3** and **4**, are to be submitted and approved before the work is commenced. And, the Society, where considered necessary, may require further plans and documents other than those specified below.

3. Plan and data for approval

In addition to **Ch 4, 203. 3** of **the Rules**, the following plans and documents are to be submitted.
(1) Arrangement plan required by **Ch 4, 203. 3** (1) of **the Rules** is also to include the followings;
  (A) Toxic zone
  (B) Spaces where ammonia treatment systems are installed
(2) Following plans and data of ammonia treatment systems
  (A) Specification of ammonia treatment systems
  (B) Calculation of ammonia treatment system capacity

4. Plans and documents for reference

In addition to **Ch 4, 203. 4** of **the Rules**, the following plans and documents are to be submitted.
(1) Design pressure calculation formula for pressurize type of fuel tank where temperature control measures are not provided
(2) Data for analysis of dispersion and/or ventilation, if required
(3) Calculation of ammonia bilge tank capacity
(4) The operation manual is to include response procedure for emergency ammonia release and ammonia effluent discharge methods.

Section 3 Periodical Surveys

Ch 4, Sec 3 of **the Rules** is to be applied. ⚓

CHAPTER 5 SHIP DESIGN AND ARRANGEMENT

Section 1 General

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

Section 2 Functional Requirements

In addition to **Ch 5, Sec 2** of **the Rules**, the followings are to be applied;

1. In applying **Ch 5, 201. 2** of **the Rules**, The released gases are not to present significant health hazard and direct gas release to the atmosphere is not permitted during normal operation.

   (Note) Release during the normal operation in this context means release during fuel bunkering, fuel processing, purging and vent from fuel systems and ventilation discharges form toxic zone etc.

Section 3 Arrangement of Fuel Tanks

Ch 5, Sec 3 of **the Rules** is to be applied.

Section 4 Arrangement of machinery space

401. Gas safe machinery space

1. A single failure of fuel systems is not to lead to a gas release in the machinery space. That is, only gas safe machinery space concept is accepted.
2. Gas safe machinery space concept is to be in accordance with **Ch 5, 401. 1** of **the Rules**.

Section 5 Gas Safe Machinery Space

Ch 5, Sec 5 of **the Rules** is to be applied.

Section 6 ESD-Protected Machinery Spaces

ESD protected machinery space concept is not be permitted.

Section 7 Location and protection of fuel piping

Ch 5, Sec 3 of **the Rules** except **701. 4** and **5** is to be applied.

Section 8 Fuel Preparation Room

Ch 5, Sec 8 of **the Rules** is to be applied.

Section 9 Bilge Systems

In addition to the requirements in **Ch 5, Sec 9** of **the Rules**, the following apply:

1. Separate bilge tanks are to be installed to accommodate bilge where fuel may exist.

Section 10 Drip Trays

In addition to the requirements in **Ch 5, Sec 10** of **the Rules**, the following apply:

1. In applying **Ch 5, 1001.1** of **the Rules**, Drip trays containing fuel spill are to be equipped with means to detect leakage and shut off the fuel if required by the risk assessment.
2. **Ch 5, 1001.1** of **the Rules** does not apply.

Section 11 Arrangement of Entrances and Other Openings in Enclosed Spaces

Ch 5, Sec 11 of **the Rules** is to be applied. ⚓

Section 12 Airlocks

Ch 5, Sec 12 of **the Rules** is to be applied. ⚓

CHAPTER 6 FUEL CONTAINMENT SYSTEM

Section 1 General

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 fuelled ship.

Section 2 Functional Requirements

In addition to the requirements in **Ch 6, Sec 2** of **Rules for the Classification of Ships Using Low-flashpoint Fuels**, the following apply:

1. In applying **Ch 6, 301. 1** of **the Rules**, the following potential dangers are also to be considered;
   (1) personnel exposure to higher concentration of ammonia gas than permissible exposure limit
   (2) ammonia gas spread to non-toxic zone
2. Portable ammonia fuel tank is not acceptable to avoid possible gas leakage. Therefore **Ch 6, 201. 4** of **the Rules** does not apply.

Section 3 General Requirements

In addition to the requirements in **Ch 6, Sec 3** of **the Rules**, the following apply:

1. In applying **Ch 6, 301. 1** of **the Rules**, ammonia may be stored with a maximum allowable relief valve setting (MARVS) of over 1.0 MPa.
2. In applying **Ch 6, 301. 4** of **the Rules**, the fuel tank connections located in enclosed space are to be installed in a tank connection space provided separately from a fuel storage hold space. For the fuel tank located on open deck, a tank connection space is also to be provided where escaped gas may accumulate on open deck or enter in non-toxic zone such as accommodation space and machinery space based on the risk assessment. Where tank connection space is provided, drip tray specified in **Ch 6, 301. 10** of **the Rules** does not apply.

Section 4 Liquefied gas fuel containment

In addition to the requirements in **Ch 6, Sec 4** of **the Rules**, the following apply:

1. In applying **Ch 6, 409. 3** (3) (A) (b) of **the Rules**, design vapour pressure P_0 is not to be less than the gauge vapour pressure corresponding to a maximum temperature of fuel that may be increased due to heat ingress from the upper ambient design temperatures.
2. In applying **Ch 6, 413.** of **the Rules, Ch 7, Sec.2** of this guidelines should be taken into account.

Section 5 Portable Liquefied Gas Fuel Tanks

Portable ammonia fuel tank is not accepted.

Section 6 Compressed Petroleum Gas Fuel Containment

As storage in compressed gas form is not applicable for ammonia.

Section 7 Pressure Relief System

701. General

Ch 6, 701. of **the Rules** is to be applied.

702. Pressure relief systems for liquefied gas fuel tanks

In addition to the requirements in **Ch 6, 702.** of **the Rules**, the following apply:

1. In applying **Ch 6, 702. 8** of **the Rules**, the outlet from the pressure relief valves is to normally be located to prevent discharged gas from entering air intake, air outlet or opening to accommodation, service and control spaces, or other non-hazardous area and non-toxic zone. These location is to be satisfied through the followings;
   (1) Release during normal operation
      (A) Vent line is to lead to ammonia treatment systems that are automatically activated by gas detection at outlet of pressure relief valves and reduce the amount of released gas. The concentration of released gas to atmosphere is to be less than 300 ppm.
      (B) Openings of non-toxic zones are to be away from the boundary maintained up to 25 ppm.
   (2) Release in emergency case such as fire or collision where is not practical to meet (1) above.
      (A) Alternative design in accordance with **Ch 1, 103** may be acceptable to prevent the gas from entering the non-toxic zone, or
      (B) The provision a space that is designed and equipped to protect personnel from the effect of a major fuel release and emergency response procedure is to be provided as a means of personnel escape.
2. In applying **Ch 6, 702. 10** of **the Rules**, to prevent gas from escaping through the drain line, a warning mark is to be provided on the drain valve to check for the presence of ammonia gas in the vent pipe system before opening the drain valve.

703. Sizing of pressure relieving system

Ch 6, 703. of **Rules for the Classification of Ships Using Low-flashpoint Fuels** is to be applied.

Section 8 Loading Limit for Liquefied Gas Fuel Tanks

Ch 6, Sec8 of **the Rules** is to be applied.

Section 9 Maintaining of fuel storage condition

901. Control of tank pressure and temperature

In addition to the requirements in **Ch 6, Sec 9** of **the Rules**, the following apply:

1. In applying **Ch 6, 901. 1** of **the Rules**, for the pressurized tank, 'the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature' is to apply the gauge vapour pressure corresponding to a maximum temperature of fuel that may be increased due to heat ingress from the upper ambient design temperatures.
2. With the exception of **Par 1**, control means of tank pressure and temperature in accordance with **Ch 6, 901. 1** of **the Rules** are to be provided.

Section 10 Atmospheric Control within the Fuel Containment System

Ch 6, Sec 10 of **the Rules** is to be applied.

Section 11 Atmosphere Control within Fuel Storage Hold Spaces (Fuel Containment Systems other than Type C Independent Tanks)

In addition to the requirements in **Ch 6, Sec 11** of **the Rules**, the following apply:

1. In applying **Ch 6, 1101.** of the Rules, the spaces referred to in **Par 1** may be filled with a suitable dry air.

Section 12 Environmental control of spaces surrounding type C independent tanks

Ch 6, Sec 12 of **the Rules** is to be applied.

Section 13 Inerting

Ch 6, Sec 13 of **the Rules** is to be applied.

Section 14 Inert Gas Production and Storage on Board

Ch 6, Sec 14 of **the Rules** is to be applied. ⚓

CHAPTER 7 MATERIAL AND GENERAL PIPE DESIGN

Section 1 General

1. In addition to the requirements in **Ch 7** of **the Rules**, this Chapter is to be complied with.
2. In the case of items not specified in this Chapter and **the Rules**, the requirements specified in **Pt 2** of **Rules for the classification of steel ships** are to be applied.

Section 2 Special requirements due to fuel

201. Special requirements due to fuel

1. containment and process systems made of carbon-manganese steel or nickel steel

(1) Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon-manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in (2) to (8) is to be taken, as appropriate.

(2) Where carbon-manganese steel is used, cargo tanks, process pressure vessels and cargo piping are to be made of fine-grained steel with a specified minimum yield strength not exceeding 355 $\mathrm{N/mm^2}$, and with an actual yield strength not exceeding 440 $\mathrm{N/mm^2}$. One of the following constructional or operational measures is also to be taken:

(A) lower strength material with a specified minimum tensile strength not exceeding 410 $\mathrm{N/mm^2}$ is to be used; or

(B) cargo tanks, etc., are to be post-weld stress relief heat treated; or

(C) carriage temperature is to 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

(D) the ammonia is to contain not less than 0.1 % $\mathrm{w/w}$ water, and the master is to be provided with documentation confirming this.

(3) If carbon-manganese steels with higher yield properties are used other than those specified in (2), the completed cargo tanks, piping, etc., are to be given a post-weld stress relief heat treatment.

(4) Process pressure vessels and piping of the condensate part of the refrigeration system are to be given a post-weld stress relief heat treatment when made of materials mentioned in (1).

(5) The tensile and yield properties of the welding consumables are to exceed those of the tank or piping material by the smallest practical amount.

(6) Nickel steel containing more than 5 % nickel and carbon-manganese steel, not complying with the requirements of (2) and (3), are particularly susceptible to ammonia stress corrosion cracking and are not to be used in containment and piping systems for the carriage of this product.

(7) Nickel steel containing not more than 5 % nickel may be used, provided the carriage temperature complies with the requirements specified in (2) (C).

(8) To minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 $\mathrm{ppm\ w/w}$. 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 3** below:

Table 3 Average amount of oxygen as transport temperature

T (°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

Oxygen percentages for intermediate temperatures may be obtained by direct interpolation.

2. Materials capable of highly corrosion(copper, zinc, cadmium, or their alloys) are to be not used at locations where ammonia comes in contact. It reacts strongly with copper or copper alloy, so be especially considered.
3. Rubber, plastic, vinyl or aluminium alloys, etc. is to be accepted by the Society considering the service conditions.
4. Materials that can form explosive compounds such as silver, gold, mercury and thallium are to be not used at locations where ammonia comes in contact.
5. The design pressure of the pressure vessel and piping system handling ammonia is to be greater than the maximum operating pressure by the fuel. ⚓

CHAPTER 8 BUNKERING

Section 1 Goal

The goal of this Chapter 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.

Section 2 Functional Requirements

In addition to **Ch 8, 201.** of **the Rules**, the followings are to be applied;

1. Bunkering systems are to be suitable temperature, pressure and composition of all expected ammonia.
2. Means are to be provided to manage vapour generated during bunker transfer. Where means of vapour management are not provided in accordance with **Ch 6, 901.**, vapour return connection is to be fitted at bunkering manifold.

Section 3 Bunkering Station

301. General requirements

In addition to **Ch 8, 301.** of **the Rules**, the followings are to be applied;

1. Bunkering station is to be provided with gas detectors which activate alarm at a gas vapour concentration of 25 ppm and activate ESD and water mist systems specified in **Para 2** below at a gas vapour concentration of 300 ppm.
2. The following water mist systems be installed above a bunkering manifold.
   (1) The capacity of the water mist system is to be sufficient to dissolve any spilled fuel.
   (2) The water mist system is to be capable of remotely operated at bunkering control station.
   (3) Bilge generated by the operation of the water mist system is to be lead to ammonia bilge tanks.
3. Bunkering manifolds are to be observable from bunkering control station by providing permanent watch or CCTV during bunker transfer.
4. **Ch 8, 301. 6** of **the Rules** does not apply.

302. Ships' fuel hoses

Ch 8, 302. of **the Rules** is to be applied.

Section 4 Manifold

Ch 8, Sec 4 of **the Rules** is to be applied.

Section 5 Bunkering System

In addition to **Ch 8, Sec 5** of **the Rules**, the following is to be applied;

1. In applying **Ch 8, 501. 3** of **the Rules**, When the gas detector in **301. 1** detects at a gas vapour concentration of 300 ppm. the remote shut-off valve is to be operated automatically and the bunkering operation is to be stopped.⚓

CHAPTER 9 FUEL SUPPLY TO CONSUMERS

Section 1 Goal

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

Section 2 Functional Requirements

In addition to **Ch 9, 201.** of **Rules for the Classification of Ships Using Low-flashpoint Fuels**, the followings are to be applied;

1. Fuel supply systems are to be able to supply fuel at the required pressure, temperature and flow rate.
2. Where fuel supply systems supply ammonia in the liquid phase, purging, drain, vent and leakage are to be subject to special consideration to provide an equivalent level of safety of fuel in the gas phase.
3. Fuel supply systems are design to be prevented unintended phase changes in processing of fuel supply to consumers considering vapour pressure at the working temperature as the followings;
   (1) Where fuel is supplied in the gaseous state, measures are to be taken so that the temperature of fuel is not lowered to the dew point at the working pressure.
   (2) Where fuel is supplied in the liquid state, measures are to be taken so that the pressure of fuel is not lowered to the vapour pressure at the working temperature.
4. Vent, purging and bleed lines of fuel supply systems are to be so designed as to prevent ammonia gas from being directly released to the atmosphere.

Section 3 Redundancy of Fuel Supply

Ch 9, Sec 3 of **the Rules** is to be applied.

Section 4 Safety Functions of Gas Supply System

In addition to **Ch 9, 401.** of **the Rules**, the followings are to be applied;

1. Where fuel supply systems supply fuel in the liquid phase, vent pipes and bleed lines are to be led to the fuel tank, knock out drum or equivalent devices to prevent liquid fuel from being released to the atmosphere. In addition, ammonia gas is not to be directly released to the atmosphere, but is to be release after reducing the concentrate to upper concentration limit of release through the ammonia treatment systems specified in **Ch 13**.

Section 5 Fuel Distribution Outside of Machinery Space

In addition to **Ch 9, 501.** of **the Rules**, the followings are to be applied;

1. Fuel pipes in areas on open deck shall be protected by a secondary enclosure where means of leakage detection is fitted.
2. **501. 2** of **the Rules** is not applicable and fuel vent pipes passing through enclosed space are to be protected by a secondary enclosure required in **501. 1** of **the Rules.**

Section 6 Fuel Supply to Consumers in Gas-safe Machinery Spaces

Ch 9, Sec 6 of **Rthe Rules** is to be applied.

Section 7 Fuel Supply to Consumers in ESD-protected Machinery Spaces

As ESD protected machinery space concept is not be permitted.

Section 8 Design of Ventilated Duct, Outer Pipe Against Inner Pipe Gas Leakage

In addition to **Ch 9, Sec 8** of **the Rules**, the followings are to be applied;

1. In applying **802. 1** of **the Rules**, the followings is to be applied;:

k = C_p/C_v constant pressure specific heat divided by the constant volume specific heat (1.32 for Ammonia)

Section 9 Compressors and Pumps

Ch 9, Sec 9 of **the Rules** is to be applied. ⚓

CHAPTER 10 POWER GENERATION INCLUDING PROPULSION AND OTHER GAS CONSUMER

In addition to **Ch 10** of **the Rules**, this Chapter is to be complied with.

Section 1 Funtional Requirements

In addition to **Ch 10, 201** of **the Rules**, the followings are to be applied;

1. Fuel consumers are to be designed so that ammonia gas is not to be directly released to the atmosphere under normal operation.

Section 2 Internal Combustion Engines of Piston Type

201. General

In addition to **Ch 10, 301** of **the Rules**, the followings are to be applied;

1. A detailed evaluation regarding the following potential source of fuel gas release is to be carried out and reflected in the safety concept of the engine.

(1) unburned gas form exhaust gas outlet
(2) vent outlet of crank case and sump
(3) vent outlet of lubricate oil and cooling water systems

2. According to the evaluation of **Para 1** above, a gas detector that alarms at 25 ppm and stops the engine at 300 ppm should be installed in the source of possible gas release.

⚓

CHAPTER 11 FIRE SAFETY

In addition to **Ch 11** of **the Rules**, this Chapter is to be complied with.

Section 1 Fire Main

101. Fire main

1. In applying **Ch 11 401. 1** of **the Rules**, the water mist systems required ammonia treatments systems may be part of the fire main system provided that the required fire pump capacity and working pressure are sufficient for both of the operation of ammonia treatment systems in **Ch 13** and the operation specified in **Ch 11 401. 1** of **the Rules** simultaneously. ⚓

CHAPTER 12 EXPLOSION PREVENTION

In addition to **Ch 12** of **the Rules**, this Chapter is to be complied with.

Section 1 Hazardous Area Zones

In lieu of **Ch 1, 101. 18** of the **Rules,** the followings are to be applied;

101. Zone "0"

Ch 12, 501. of **the Rules** is to be applied.

102. Zone "1" 【See Guidance】

This zone includes, but is not limited to:

1. tank connection spaces, fuel storage hold spaces(Fuel storage hold spaces for type C tanks are normally not considered as zone "1") and interbarrier spaces;
2. fuel preparation room arranged with ventilation according to **Ch 14, 601.**;
3. enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations; and
4. a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone "1"

103. Zone "2" 【See Guidance】

This zone includes, but is not limited to:

1. space containing bolted hatch to tank connection space. ⚓

CHAPTER 13 PREVENTION OF EXPOSURE TO TOXICITY

Section 1 Goal

The goal of this Chapter is to protect personnel from ammonia gas released from sources of release.

Section 2 Functional Requirements

201. Functional Requirements

This section is related to functional requirements in **Ch 2, 201. 1**, **2** and **3**. In particular the following apply.

1. Sources of ammonia release are to be as minimum.

2. Means to protect personnel from all ammonia release scenario including emergency release is to be provided.

3. The concentration limit of released ammonia gas is to meet the followings.

(1) The permissible concentration of ammonia gas to which personnel may be exposed is to be limited up to 25 ppm, and personnel is to be prohibited from entering an space where the gas concentration exceeds 25 ppm.

(2) Except for the purpose of tank protection in case of emergency, the concentration of released ammonia gas is not to exceed 300 ppm.

4. Released ammonia gas is not to ingress to non-toxic zone.

Section 3 General Requirements

301. Permissible exposure limit

1. In this guideline, the permissible exposure limit is 25 ppm.

2. This limit of 25 ppm is reference value for detection alarm and toxic zone.

302. Upper concentration limit of release

1. The upper concentration limit of release that is not to be released to atmosphere in this guideline is 300 ppm.

2. This limit of 300 ppm is reference value for activation of emergency shutdown and ammonia treatment systems.

303. Prevention of the spread of ammonia gas

1. Gas released from sources of release in open area is not to enter through openings in non-toxic zone.

2. Gas discharge from ventilation of enclosed spaces having sources of ammonia gas are not to enter through openings of non-toxic zone.

304. Prevention of ammonia gas release to atmosphere

1. Direct ammonia release to atmosphere during normal operating is to be prohibited. The following releases are to be directed to the fuel supply system or to the ammonia treatment systems.

(1) purging of ammonia fuel pipe for fuel change-over

(2) release from a bleed valve

(3) discharge from the pressure relief valve fitted at the fuel supply system

2. Concentration of ammonia gas discharged from ventilation outlets in spaces with sources of ammonia leakage is to be limited to less than 300 ppm. This concentration can be limited through the ammonia treatment system.

3. Venting of fuel vapour for control of the tank pressure is not acceptable during bunkering and operation except in emergency situation(e.g. fire, collision, etc.).

305. Toxic Zone

1. Enclosed spaces where sources of release are installed and open areas around sources of release are to be defined as toxic zone. The definition of the toxic zone is given in Sec 4.

2. Openings of gas safety zones are to be arranged away from toxic zones.

3. Toxic zones adjacent to non-toxic zone is to maintain a lower pressure than non-toxic zone.

Section 4 Toxic Zone Classification

401. General

1. In this section, the toxic zone is defined as the area where the concentration of ammonia gas can be maintained up to 25 ppm.

2. Gas dispersion analysis may be performed to define the toxic zone, and in this case, the most stringent conditions are applied for the boundary conditions (release rate, gas specific gravity, etc.) of the released gas in consideration of the system design and environmental conditions.

402. Toxic Zone

Toxic zone includes, but is not limited to:

1. Enclosed and semi-enclosed areas where gas leak sources are installed

2. the following areas on open dock where gas leak sources are installed
   (1) area within 10 m from the ventilation outlet of the area specified in Para1
   (2) area within 6 m from other openings in spaces specified in Para 1.
   (3) area within 25 m from vent mast outlet, however, in case of emergency, the toxic zone is determined in accordance with Para 3.
   (4) area within 10 m from coaming surrounding bunkering manifold
   (5) area within 10 m from release sources such as valves, flanges, etc. of fuel piping on open deck

3. As an alternative to the definition in Para 2, the area on the open deck where the concentration of ammonia gas is greater than 25 ppm from the following gas release sources through gas dispersion analysis based on the the most stringent boundary conditions.
   (1) ventilation outlet or other openings of the spaces specified in Para 1
   (2) vent mast exit
   (3) bunkering manifold
   (4) release sources such as valves, flanges, etc. fuel piping on open deck

Section 5 Personnel Protection

501. General

1. For the protective equipment, safety equipment and emergency equipment, the kind and quantity is added or reduced when deemed appropriate by the Society, if required in accordance with the relevant requirements of **Pt 7, Ch 5, Ch 6** of **Rules for the classification of steel ships.**

2. The place where equipment for personal protection is stored is to be located where the toxicity of fuel does not reach.

502. Protective equipment

1. For the protection of crew members who are engaged in operations related fuel, the ship should have on board suitable protective equipment consisting of large aprons, special gloves with long sleeves, suitable footwear, coveralls of chemical-resistant material, and tight-fitting goggles or face shields or both. The protective clothing and equipment should cover all skin so that no part of the body is unprotected.

2. Work clothes and protective equipment should be kept in easily accessible places and in special lockers. Such equipment should not be kept within accommodation spaces, with the exception of new, unused equipment and equipment which has not been used since undergoing a thorough cleaning process. The Society may, however, approve storage rooms for such equipment within accommodation spaces if adequately segregated from living spaces such as cabins, passageways dining rooms, bathrooms, etc.

3. Protective equipment should be used in any operation which may entail danger to personnel.

503. Safety equipment

1. Sufficient, but not less than three complete sets of safety equipment are to be provided to permit entry and work in a gas-filled space. Each complete set of safety equipment is to consist of:
   (1) one self-contained positive pressure air-breathing apparatus incorporating full face mask, not using stored oxygen and having a capacity of at least 1,200 ℓ of free air. Each set is to be compatible with that required by **Pt 8 Ch 8 Sec 9** of **Rules for the classification of steel ships**
   (2) protective clothing, boots and gloves to a recognized standard
   (3) steel-cored rescue line with belt
   (4) explosion-proof lamp.

2. An adequate supply of compressed air is to be provided and is to consist of:
   (1) at least one fully charged spare air bottle for each breathing apparatus required by **1**
   (2) an air compressor of adequate capacity capable of continuous operation, suitable for the supply of high pressure air of breathable quality
   (3) a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by **1**.

504. Emergency equipment

1. Emergency equipment shall be provided with suitable respiratory and eye protection sufficient for every person on board for emergency escape purposes, subject to the following:
   (1) filter type respiratory protection is unacceptable;
   (2) self-contained breathing apparatus shall have normally at least a duration of service of 15 min; and
   (3) emergency escape respiratory protection shall not be used for fire-fighting or cargo handling purposes and shall be marked to that effect.

2. The ships shall have on board medical first-aid equipment including oxygen resuscitation equipment and antidotes for cargoes carried, based on the guidelines developed by IMO.

3. A stretcher which is suitable for hoisting an injured person up from spaces such as the fuel preparation room shall be placed in a readily accessible location.

4. Suitably marked decontamination showers and an eyewash shall be installed in areas that may handle the fuel (bunkering station, opening of tank connection space, opening of fuel preparation room and etc.). The showers and eyewash shall be operable in all ambient conditions.

Section 6 Ammonia Gas Treatment Systems

601. General

1. Ammonia treatment systems are to be installed for the following source of release to limit the release of ammonia to the atmosphere.

(1) The following ammonia discharge lines from the fuel system:
  (A) purging line of fuel piping system
  (B) pressure relief line of fuel piping system
  (C) bleed line of fuel piping system
(2) following spaces or area containing ammonia systems:
  (A) fuel preparation room
  (B) tank connection space
  (C) double wall pipe space
  (D) bunkering stations
(3) fuel tank vent

2. The ammonia treatment system may be one of the following;
  (1) scrubber
  (2) gas absorption water tank
  (3) water mist system
  (4) gas combustion unit

3. The ammonia bilge generated from the scrubber, gas absorbing water tank and water mist system is to be directed to the ammonia bilge tank. However huge amount of the ammonia bilge generated in emergency case such as fire or collision where is not practical to be led to the ammonia bilge tank may be discharged overboard.

602. Scrubber

1. The scrubber is to be designed with an adequate processing capacity which restricts the gas concentration at the outlet to below 25 ppm.

2. The pump for the scrubber is to start automatically when the gas concentration in the inlet of scrubber exceeds 300 ppm.

603. Gas absorption water tank

1. The ammonia discharge pipe is to be located below the water level in the tank and the distance from the water level is to be subject of consideration of the back pressure of head.

2. If the concentration of ammonia at the outlet of the water tank vent exceeds 25 ppm, the water in the tank is to be transferred to the ammonia bilge tank and the tank is to be refilled with fresh water or sea water.

604. Water mist system

1. The capacity of the water mist system is to be able to absorb the maximum amount of leaked gas.

2. If the concentration of ammonia gas in the protected compartment exceeds 300 ppm, the pump of the water mist device is to operate automatically.

3. Ammonia effluents are to be led to a ammonia bilge tank.

Section 7 Ammonia Bilge Tanks

701. General

1. Ammonia bilge tanks are not to be installed in machinery spaces.

2. Ammonia bilge tanks are to be separated from adjacent spaces by cofferdams.

702. Vent

1. The vent of the ammonia bilge tank is to be connected to the vent mast.

2. A gas detector is to be installed in the vent of the ammonia bilge tank. If the gas concentration in

the vent exceeds 300 ppm, the vent pipe is to be directed to a gas treatment system

703. Discharge to sea

1. The ammonia effluents may be discharged to the sea after diluted or neutralized. Discharge standards and procedure are to be in accordance with MARPOL Annex II Ch. V. The national regulation, if any, of the coastal state in which the ship is located is also to be applied,

CHAPTER 14 VENTILATION

Section 1 Goal

The goal of this Chapter is to provide for the ventilation required for safe operation of ammonia-fuelled machinery and equipment.

Section 2 Functional Requirements

In addition to **Ch 13, Sec 2** of **the Rules**, the followings are to be applied;

1. Capacity and layout of ventilation system are to be so designed that efficiency of ventilation is ensured considering that the density of ammonia increases in the higher humidity.
2. Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation should be located such that according to the International Convention on Load Lines they will not be required to have closing appliances.
3. Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where the fuel may accumulate should be capable of being ventilated to ensure a safe environment. Before entering these spaces, the presence of ammonia gas should be checked.

Section 3 General Requirements

In addition to **Ch 13, Sec 3** of **the Rules**, the followings are to be applied;

1. A term 'hazardous spaces' used in **Ch 13 Sec3** of **the Rules** includes toxic spaces.
2. **Ventilation of hazardous spaces**
   (1) Ventilation ducts serving hazardous areas are not to be led through accommodation, service space, machinery space, control stations and ro-ro space, except as allowed in **Ch 13, Sec 8** of **the Rules**.
   (2) The number and location of the ventilation outlets in each space are to be considered taking into account the size, layout of the space. If necessary, it is to be demonstrated based on ventilation analysis that capacity and duct arrangements of ventilation are adequate for the space.
3. The air outlet of the hazardous area should be located in a safe place where it does not affect the crew in consideration of the toxicity of ammonia.

Section 4 Tank Connection Space

Ch 13, Sec 4 of **the Rules** is to be applied.

Section 5 Machinery Spaces

The ventilation system for machinery spaces containing gas-fuelled consumers is to be independent of all other ventilation systems. the Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine-room workshops and stores) are considered an integral part of machinery spaces containing gas-fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces.

Section 6 Fuel Preparation Room

In addition to **Ch 13, 601.** of **the Rules**, the followings are to be applied;

1. In applying **Ch 13, 601.** of **the Rules**, type approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the fuel preparation room.

Section 7 Bunkering station

Ch 13, Sec 7 of **the Rules** is to be applied.

Section 8 Ducts and Double Pipes

In addition to **Ch 13, 801.** of **the Rules**, the followings are to be applied;

1. In applying **Ch 13, 801. 1** of **Rhe Rules**, ventilation inlets and outlets of double wall piping and ducts are to be located so that negative pressures is maintained in the whole space between inner pipes and outer ducts/pipes.
2. In applying **Ch 13, 801. 3** of **the Rules**, the ventilation inlets for the double wall piping and ducts are always to be located in a non-hazardous open area away from ignition sources. ⚓

CHAPTER 15 ELECTRICAL INSTALLATIONS

Section 1 Goal

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

Section 2 Functional Requirements

Ch 14, Sec 2 of **the Rules** is to be applied.

Section 3 General Requirements

In addition to **Ch 14, Sec 3** of **the Rules**, the followings are to be applied;

1. In applying **Ch 14, 301. 3** of **the Rules**, equipment for hazardous areas is to be of a certified safe type appropriate for ammonia in accordance with **IEC 60079-20,** classifies the temperature class and equipment groups for ammonia as the followings;

	Temperature class	Equipment group
Ammonia	T1	IIA

2. In the case of hazardous areas with gas detection and safety systems(25 ppm for alarm, 300 ppm for emergency shutdown), certified safe type is not required for electrical equipment that automatically disconnected at 40% LEL.

CHAPTER 16 CONTROL, MONITORING AND SAFETY SYSTEMS

Section 1 Goal

The goal of this Chapter is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the gas-fuelled installation as covered in the other chapters of this Guidelines.

Section 2 Functional Requirements

This Chapter is related to functional requirements in **1, 2, 3, 9, 10, 11, 14, 15** and **18** of **201., Ch 2 the Rules**. In particular the following apply.

1. the control, monitoring and safety systems of the gas-fuelled installation are to be so arranged that the remaining power for propulsion and power generation is in accordance with **Ch 9, 301.** of **the Rules** in the event of single failure;
2. a gas safety system is to be arranged to close down the gas supply system automatically, upon failure in systems as described in **Table 4** and upon other fault conditions which may develop too fast for manual intervention;
3. the safety functions are to be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common cause failures. This includes power supplies and input and output signal;.
4. the safety systems including the field instrumentation are to be arranged to avoid spurious shutdown, e.g. as a result of a faulty gas detector or a wire break in a sensor loop; and
5. where two or more gas supply systems are required to meet the regulations, each system is to be fitted with its own set of independent gas control and gas safety systems.

Section 3 General Requirements

In addition to **Ch 15, Sec 3** of **the Rules**, the followings are to be applied;

1. A bilge well in fuel storage hold spaces of independent tanks other than type C is to be provided with both a level indicator and a temperature sensor. Alarm is to be given at high level in the bilge well. Low temperature indication is to activate the safety system.
2. When a dedicated storage tank for fuel leakage is installed, a level indicator and alarm device should be installed.

Section 4 Bunkering and Liquefied Gas Fuel Tank Monitoring

Ch 15, Sec 4 of **the Rules** is to be applied.

Section 5 Bunkering Control

Ch 15, Sec 5 of **the Rules** is to be applied.

Section 6 Gas Compressor Monitoring

Ch 15, Sec 6 of **the Rules** is to be applied.

Section 7 Gas Engine Monitoring

Ch 15, Sec 7 of **the Rules** is to be applied.

Section 8 Leak Detection

801. Gas detection

1. Permanently installed gas detectors are to be fitted in:

(1) the tank connection spaces;
(2) interbarrier spaces and fuel storage hold spaces of independent tanks other than type C;
(3) cofferdams adjacent to fuel tanks;
(4) fuel preparation rooms;
(5) all ducts and double pipes containing fuel piping for outside the machinery space;
(6) machinery spaces containing gas piping, gas equipment or gas consumers;
(7) other enclosed spaces containing fuel piping or other fuel equipment without ducting;
(8) motor rooms associated with the fuel systems;
(9) airlocks;
(10) fuel heating circuit expansion tanks;
(11) closed or semi-enclosed bunkering station;
(12) at ventilation inlets to accommodation, machinery spaces, control stations and service spaces if required based on the result of the gas dispersion analysis;
(13) outlet of ammonia treatment system; and
(14) vent outlet of pressure relief valve of fuel tank

2. The number of detectors in each space are to be considered taking into account the size, layout and ventilation of the space.

3. The detection equipment is to be located where gas may accumulate and in the ventilation outlets. Gas dispersal analysis or a physical smoke test is to be used to find the best arrangement.

4. Gas detection equipment is to be designed, installed and tested in accordance with **IEC 60079-29-1** and **EN 45544-4,** or equivalent.

5. For tank connection space, an audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm. The safety system such as closing of tank valve and shutdown of fuel pump is to be activated at 300 ppm at two detectors.

6. For fuel preparation room, an audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm. The safety system such as shutdown of fuel supply system is to be activated at 300 ppm at two detectors.

7. For ducts and double pipes containing fuel pipes outside the machinery space, an audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm. The safety system such as shutdown of fuel supply system is to be activated at 300 ppm at two detectors.

8. For ducts and double pipes containing fuel pipes in the machinery space, an audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm. The safety system such as closing of main fuel valve is to be activated at 300 ppm at two detectors.

9. For bunkering station, an audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm. The valves related bunkering are to be closed at 300 ppm at two detectors.

10. An audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm at the detector required by Para 1 (9).

11. An audible and visible alarm is to be activated at a gas vapour concentration of 25 ppm and to close ventilation inlet of the space at 110 ppm at the detector required by Para 1 (12).

12. Audible and visible alarms from the gas detection equipment are to be located on the navigation bridge or in the continuously manned central control station. If necessary, alarms from the gas detection equipment are to be activated at location adjacent to the exit of outside the protected space where the gas detector is installed to prevent the crew from entering the area where ammonia leaked.

13. Gas detection required by this Section is to be continuous without delay.

802. Low temperature detection

In cases where it is effective to detect a liquid leakage in ducts and double pipes containing liquid fuel piping, low temperature detection system may be installed. When a leak is detected, all related valves are to be closed to prevent leakage.

Section 9 Fire Detection

Required safety actions at fire detection in the machinery space containing ammonia-fuelled engines and rooms containing independent tanks for fuel storage hold spaces are given in **Table 4** below.

Section 10 Ventilation

Ch 15, Sec 10 of **the Rules** is to be applied.

Section 11 Safety Functions of Fuel Supply Systems

Ch 15, Sec 11 of **the Rules** is to be applied.

Table 4 Monitoring of fuel supply system to engines

Parameter	Alarm	Automatic shutdown of main tank valve[5)]	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Remarks
Gas detection in tank connection space at 25 ppm	X			
Gas detection on two detectors tank connection space at 300 ppm	X	X		
Fire detection in ventilation trunk to the tank connection space and in the tank connection space	X			
Bilge well high level in tank connection space	X			
Bilge well low temperature in tank connection space	X	X		
Fire detection in fuel storage hold space	X			
Gas detection in fuel preparation room at 25 ppm	X			
Gas detection on two detectors fuel preparation room at 300 ppm	X	X[1)]		
Bilge well low temperature in fuel preparation room	X		X	
Gas detection in all ducts and double pipes containing fuel piping for outside the machinery space at 25 ppm	X			
Gas detection on two detectors all ducts and double pipes containing fuel piping for outside the machinery space at 300 ppm	X	X[1)]		
Gas detection in all ducts and double pipes containing fuel piping for the machinery space at 25 ppm	X			
Gas detection on two detectors all ducts and double pipes containing fuel piping for the machinery space at 300 ppm	X		X[2)]	
Gas detection above ammonia engine in machinery space at 25 ppm	X			
Gas detection on two detectors above ammonia engine in machinery space at 300 ppm			X[2)]	
Gas detection in bunkering station 25 ppm	X			
Gas detection on two detectors in bunkering station 300 ppm	X			closed valves relating bunkering and stopped bunkering operation
Loss of ventilation in duct between tank and machinery space containing gas-fuelled engines	X	X[1)]		
Loss of ventilation in duct inside machinery space containing gas-fuelled engines[4)]	X		X[2)]	
Fire detection in machinery space containing gas-fuelled engines	X			

Table 15.1 Monitoring of fuel supply system to engines (continued)

Parameter	Alarm	Automatic shutdown of main tank valve[5)]	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Remarks
Abnormal gas pressure in gas supply pipe	X			
Failure of valve control actuating medium	X		X[3)]	Time delayed as found necessary
Automatic shutdown of engine (engine failure)	X		X[3)]	
Manually activated emergency shutdown of engine	X		X	
Gas detection in engine exhaust gas systems at 25 ppm	X			
Gas detection in engine exhaust gas systems at 300 ppm	X		X	
Gas detection in engine lubrication and cooling systems at 25 ppm	X			
Gas detection in engine lubrication and cooling systems at 300 ppm	X		X	

Note :

1) If the tank is supplying gas to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected is to close.
2) If the gas is supplied to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas-fuelled engines, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected is to close.
3) Only double block and bleed valves to be activated.(two block valves to close and a bleed valve to open)
4) If the duct is protected by inert gas (See **Ch 9, 601. 1**) then loss of inert gas overpressure is to lead to the same actions as given in this table.
5) Valves referred to in **Ch 9, 401.** of **the Rules** ⚓

CHAPTER 17 MANUFACTURE, WORKMANSHIP AND TESTING

Ch 16 of **the Rules** is to be applied. ⚓

CHAPTER 18 DRILLS AND EMERGENCY EXERCISES

In addition to **Ch 17** of **the Rules**, the followings are to be applied;

1. Ammonia fuel-related drills and exercises should be incorporated into schedule for periodical drills to be adequately qualified, trained and experienced.
   (1) Hazards due to the properties of ammonia and liquefied gas
   (2) safety actions for leakage accidents and consequences of ammonia leakage caused by careless handling of equipment
   (3) How to use protective equipment and safety equipment provided on board the ship
   (4) Location and how to use of shower facilities and eye wash stations for emergency
2. The master, officers, ratings and other personnel on ships using fuels should be trained and qualified in accordance to the regulation V/3 of the STCW Convention and section A-V/3 of the STCW Code, taking into account the specific hazards of fuel. ⚓

CHAPTER 19 OPERATION

In addition to Ch 18 of **the Rules**, the followings are to be applied;

1. Special care should be taken not to contact the ammonia to strong oxidizers such as chlorine, hypochlorite bleach, halogen-based substances to avoid potentially explosive reaction. Ammonia mixtures with oil or other combustible materials can cause a big explosion. ⚓

Annex 1 REQUIREMENTS FOR AMMONIA FUEL READY

Section 1 General

101. Application

1. This Annex applies to ships which are prepared for conversion with the design or the partial installation related with ammonia fuel during the new building phase(hereafter referred to as "ammonia fuel ready ships" in the Guidelines) for the purpose of a conversion from a ship using conventional marine fuels to ammonia fuel after delivery.
2. This Annex contains levels of readiness for use of ammonia as fuel(hereafter referred to as "ammonia fuel ready levels" in the Guidelines) and requirements applicable thereto, and the scope of preparation is defined by the agreement between the shipowner and the shipbuilder.
3. The design and the installation of ammonia fuel systems of ammonia fuel ready ships are to apply this Guidelines in force at the time of contract for construction for the new-building. However, where a ammonia fuel ready ship in accordance with this Guidelines is converted to a ammonia fuelled ship after delivery, the ship shall comply with this Guidelines in force at the time of the ship conversion.

102. Ammonia fuel ready levels

1. Ammonia fuel ready levels are defined in 3 steps as follows:
   (1) The level of preparing the concept design
   (2) The level of preparing the generic design
   (3) The level of installing parts of the systems with the detailed design in addition to above (1)
2. The class notations defined in **Sec 2** may be assigned where the ready level in **Para 1** is in compliance with this Annex.

Section 2 Class Notation

201. General

1. The class notations specified in **202.** and **205.** may be assigned according to the ammonia fuel ready level
2. The requirements for the class notations in this Section are to comply with **Sec 3**.

202. Ammonia Ready D(A)

1. Ammonia Ready D(A) as an additional special feature notation may be assigned to ships whose the ammonia fueled ship concept design is prepared for evaluation of the basic suitability.
2. Ammonia Ready D(A) is not to be assigned to ships having LNG Ready D.

203. Ammonia Ready D

1. Ammonia Ready D as an additional special feature notation may be assigned to ships for which the generic design is prepared.
2. Ammonia Ready D is not to be assign to ships having Ammonia Ready I.

204. Ammonia Ready I

1. Ammonia Ready I as an additional special feature notation may be assigned to ships for which parts of the systems are installed with the detailed design in addition to the generic design.
2. In assignment of the Ammonia Ready I, the characters corresponding to the installed items may be

assigned in the bracket one or a combination of them in addition to Ammonia Ready I. The characters corresponding to the installed items are as follows:

(1) Hull structural reinforcement for ammonia fuel tank - SR
(2) Ammonia fuel tank - FT
(3) Ammonia fuel tank venting systems - TV
(4) Ammonia fuel supply systems - FS
(5) Ammonia fuel bunkering systems - BS
(6) Ammonia fired main engines - ME
(7) Ammonia fired auxiliary engines - AE
(8) Ammonia fired boilers - B
(9) Main engines that can be converted to Ammonia fuel operation - ME-C
(10) Auxiliary engines that can be converted to Ammonia fuel operation - AE-C
(11) Boilers that can be converted to Ammonia fuel operation - B-C
(12) Ammonia treatment systems - AT

For example, Ammonia Ready I(SR, FT) may be assigned to the ship on which structural reinforcement for ammonia fuel tank and ammonia fuel tank are installed, and Ammonia Ready I(FS, ME) may be assigned to the ship on which ammonia fuel supply systems and ammonia fired main engines are installed.

205. LPG and Ammonia Ready

LPG and Ammonia Ready D(A), LPG and Ammonia Ready D, LPG and Ammonia Ready I as an additional special feature notation may be assigned to ready ships whose prepared to use LPG fuel and ammonia fuel.

Section 3 Requirements for Levels of Ammonia Fuel Ready

301. General

1. This Guidelines prescribes plans to be submitted and systems to be installed. The design and installation of structures and systems are to be in accordance with applicable requirements in this Guidelines.
2. Drawing approval and survey for ammonia fuel ready are not accepted as drawing approval and survey for conversion to ammonia fuel ship. When the ship is converted, drawing approval and survey are to be carried out in accordance with this Guidelines in force at the time of the ship conversion. Approved Drawings and certifications from new building stage may be used as reference for conversion.

302. General Level of Preparing Concept Design

1. Plans and documents required for an Approval in Principle (AIP) are to be submitted for Ammonia Ready D(A). List of plans and documents to be submitted may be mediated after consultation with the Society.
2. The plans and documents required in this Section is to be marked "Ammonia Ready" to separate them from the normal plans and documents of new building.

303. General Level of Preparing Generic Design

1. General

(1) This Section prescribes plans and documents to be submitted for Ammonia Ready D. The detail requirements for designs are to be in accordance with applicable requirements in this Guidelines.
(2) The plans and documents required in this Section is to be marked "Ammonia Ready" to separate them from the normal plans and documents of new building.
(3) Where parts of plans and documents required in this Section are not available, alternative documents may be accepted by the Society's review.

2. Plans and documents to be submitted

(1) The following plans and documents are to be submitted to the Society for review
  (A) General arrangement plans showing location of:
    (a) Machinery spaces, accommodation, service and control station spaces
    (b) Ammonia fuel containment systems
    (c) Fuel preparation room
    (d) Ammonia fuel piping routing with shore connections
    (e) Tank hatches, ventilation pipes and any other openings to the ammonia fuel tanks
    (f) Ventilating pipes, doors and openings to fuel preparation room and other hazardous areas
    (g) Entrances, air inlets and openings to accommodation, service and control station spaces
    (h) Hazardous areas of zone 0, 1 and 2
    (j) Toxic zone
  (B) Following plans and data of the ammonia fuel containment system:
    (a) Ammonia fuel tank type, dimension and volume
    (b) Drawings of support and staying of ammonia fuel tanks
    (c) Ammonia fuel tank arrangement including tank connection space
    (d) Specification of design loads and structural analysis for the ammonia fuel tank supporting structure
    (e) Drawing and specification of ammonia fuel tank thermal insulation with heat transfer calculation
  (C) Following plans and data of ammonia fuel supply systems:
    (a) Arrangement of engine room, fuel preparation room and other spaces containing ammonia equipment
    (b) Ammonia fuel supply piping diagram
    (c) Ventilation system arrangement of engine room, fuel preparation room and other spaces containing ammonia equipment
  (D) Following plans and data of ammonia fuel bunkering systems:
    (a) Arrangement of ammonia fuel bunkering systems
    (b) Ammonia fuel bunkering piping diagram
    (c) Ventilation system arrangement of ammonia fuel bunkering station
  (E) Following plans and particulars for the safety relief valves
    (a) Arrangement for ammonia fuel tank relief valves and associated ventilation piping
    (b) Calculation of required ammonia fuel tank relief valve capacity
  (F) Following plans and data for equipment and systems regarding fire protection :
    (a) Arrangement of construction for fire protection in relation to ammonia fuel tank and other spaces containing ammonia equipment
    (b) Arrangement and specification of water spray system
    (c) Arrangement and specification of dry chemical powder installation
  (G) Data for a risk analysis according to Ch 3, Sec 2 of this Guidelines.
  (H) Stability calculations with ammonia fuel tanks included
  (I) Longitudinal strength calculations with ammonia fuel tanks included

304. Level of Installing Parts of Systems

1. General

(1) This Section prescribes parts of the systems to be installed and plans and documents to be submitted for Ammonia Ready I. The detail requirements for designs and installation of installed systems are to be in accordance with applicable requirements in this Guidelines.
(2) The plans and documents for generic design required in 303. are to be submitted and reviewed by the Society except those required for approval in Para 2 to 6.
(3) Parts of the systems are categorized in the follows:
  (A) Hull structural reinforcement for ammonia fuel tank
  (B) Ammonia fuel tank
  (C) Ammonia fuel tank venting systems
  (D) Ammonia fuel supply systems
  (F) Ammonia fuel bunkering systems
  (G) Ammonia fired main engines
  (H) Ammonia fired auxiliary engines
  (I) Ammonia fired boilers

(J) Main engines that can be converted to Ammonia fuel operation
(K) Auxiliary engines that can be converted to Ammonia fuel operation
(L) Boilers that can be converted to Ammonia fuel operation
(M) Ammonia treatment systems

(4) The parts which are installed on board are to be reflected in the normal plans of new building and "Ammonia Ready" is not to be marked on those plans.

2. Hull structural reinforcement for ammonia fuel tank

(1) The structures below the ammonia fuel tanks are to be reinforced in accordance with Ch 6 of this Guidelines.

(2) The following plans and documents are to be submitted to the Society for approval.
(A) Detail drawing of ammonia fuel tanks and support of ammonia fuel tanks
(B) Material specification for tank support and steel grade selection for the hull in way of the tank
(C) Welding procedures, stress relieving procedures and non-destructive testing plans
(D) Specification of design loads and structural analysis for the ammonia fuel tank supporting structure
(E) Drawing and specification of ammonia fuel tank thermal insulation with heat transfer calculation

3. Ammonia fuel tank

(1) Ammonia fuel tanks are to be installed in accordance with Ch 5, Sec 3 and Ch 6 of this Guidelines

(2) The plans and documents in Ch 4, 203. 3 and 4 of this Guidelines and ammonia fuel tank arrangement including tank connection space are to be submitted to the Society for approval.

4. Ammonia fuel tank venting systems

(1) Ammonia fuel tank venting systems are to be installed in accordance with Ch 5, Sec 13 and Ch 6 of this Guidelines.

(2) The plans and documents in Ch 4, 203. 3 and 4 of this Guidelines are to be submitted to the Society for approval.

5. Ammonia fuel supply systems

(1) Ammonia fuel supply systems are to be installed in accordance with Ch 7 and Ch 9 of this Guidelines.

(2) The following plans and documents are to be submitted to the Society for approval.
(A) Arrangement of engine room, fuel preparation room and other spaces containing ammonia equipment
(B) Ventilation system arrangement of engine room, fuel preparation room and other spaces containing ammonia equipment
(C) Drawings and specifications of ammonia supply piping
(D) Drawings and specifications of offsets, loops, bends and mechanical expansion joints, such as bellows, slip joints(only inside tank) or similar means in the ammonia piping
(E) Drawings and specifications of flanges, valves and other fittings in the ammonia piping system. For valves intended for piping systems with a design temperature below − 55 °C, documentation for leak test and functional test at design temperature (type test) is required
(F) Documentation of type tests for expansion components in the ammonia piping system.
(G) Specification of materials, welding, post-weld heat treatment and non-destructive testing of ammonia piping
(H) Specification of pressure tests (structural and tightness tests) of ammonia piping
(I) Program for functional tests of all piping systems including valves, fittings and associated equipment for handling ammonia (liquid or vapour)
(J) Drawings and specifications of insulation for low temperature piping where such insulation is installed
(K) Specification of electrical bonding of piping
(L) Cooling or heating water system in connection with ammonia fuel system, if fitted.

6. Ammonia fuel bunkering systems

(1) Ammonia fuel bunkering systems are to be installed in accordance with Ch 7 and Ch 8 of this Guidelines.

(2) The following plans and documents are to be submitted to the Society for approval.
(A) Arrangement of ammonia fuel bunkering systems

(B) Ventilation system arrangement of ammonia fuel bunkering station
(C) Drawings and specifications of ammonia supply piping
(D) Drawings and specifications of offsets, loops, bends and mechanical expansion joints, such as bellows, slip joints(only inside tank) or similar means in the ammonia piping
(E) Drawings and specifications of flanges, valves and other fittings in the ammonia piping system. For valves intended for piping systems with a design temperature below −55 °C, documentation for leak test and functional test at design temperature (type test) is required
(F) Documentation of type tests for expansion components in the ammonia piping system.
(G) Specification of materials, welding, post-weld heat treatment and non-destructive testing of ammonia piping
(H) Specification of pressure tests (structural and tightness tests) of ammonia piping
(I) Program for functional tests of all piping systems including valves, fittings and associated equipment for handling ammonia (liquid or vapour)
(J) Drawings and specifications of insulation for low temperature piping where such insulation is installed
(K) Specification of electrical bonding of piping
(L) Specification of means for removal of liquid contents from bunkering pipes prior to disconnecting the shore connection

7. Ammonia fired main engines

Main engines are to be installed in accordance with **Ch 10, Sec 3** of this Guidelines.

8. Ammonia fired auxiliary engines

Auxiliary engines are to be installed in accordance with **Ch 10, Sec 3** of this Guidelines.

9. Ammonia fired boilers

Boilers are to be installed in accordance with **Ch 10, Sec 4** of this Guidelines.

10. Main engines that can be converted to gas fuel operation

(1) Main engines of gas-convertible types are to be installed.
(2) Following plans are to be submitted for reference:
(A) details of the gas conversion
(B) list of the components that need to be replaced
(C) list of new components

11. Auxiliary engines that can be converted to gas fuel operation

(1) Auxiliary engines of gas-convertible types are to be installed.
(2) Following plans are to be submitted for reference:
(A) details of the gas conversion
(B) list of the components that need to be replaced
(C) list of new components

12. Boilers that can be converted to gas fuel operation

(1) Boilers of gas-convertible types are to be installed.
(2) Following plans are to be submitted for reference:
(A) details of the gas conversion
(B) list of the components that need to be replaced
(C) list of new components

13. Ammonia treatment systems

(1) Ammonia treatment systems are to be installed in accordance with **Ch 13** of this Guideline.
(2) Following plans are to be submitted for reference:
(A) Arrangement plan including spaces where ammonia treatment systems are installed
(B) Specification of ammonia treatment systems
(C) Calculation of ammonia treatment system capacity

305. Survey

1. Classification survey during construction

Systems are to be tested at the shops of manufacturer and after installation on board in accordance with this Guidelines.

2. Periodical surveys

In application of this Guidelines, the general condition of the relevant systems installed on board is to be examined visually at periodical surveys for the vessels having Ammonia Ready I notation. The systems are to be surveyed and evaluated for the condition at time of conversion, and the scope of test will be defined depending on time elapsed from new building and maintenance level of the systems. ⚓

Guidelines for Ships Using Ammonia as Fuels

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