BUREAU VERITAS MARINE & OFFSHORE

RULE NOTE

AMMONIA-FUELLED SHIPS

NR671 R03

EDITION FEBRUARY 2026

BUREAU
VERITAS

BUREAU VERITAS
MARINE & OFFSHORE
RULE NOTE

NR671 R03 FEBRUARY 2026

NR671 DT R03 February 2026 replaces the former edition September 2024.

The PDF electronic version of this document available on the Bureau Veritas Marine & Offshore website **https://marine-offshore.bureauveritas.com/** is the official version and shall prevail if there are any inconsistencies between the PDF version and any other available version.

These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

Rule Note
NR671

AMMONIA-FUELLED SHIPS

February 2026

Table of Content

Table of Content

Table of Content

Chapter 3 Ammonia Fuel Prepared Ships

Section 1 Ammonia Fuel Prepared Ships

CHAPTER 1
GENERAL

Section 1 Application

1 General

1.1 Scope

1.1.1 This Rule Note applies to ships using or prepared to use ammonia as fuel.

1.1.2 This Rule Note covers the arrangement, installation, control and monitoring of machinery, equipment and systems using ammonia as fuel, to minimize the risk to the ship, persons on board and the environment, taking into account the specific properties of ammonia, in particular its toxicity.

1.1.3 In accordance with NR467, Pt A Ch 1 Sec 2, [6.17], this Rule Note provides a set of design and installation requirements for the assignment of:

- the additional class notation **ammoniafuel**, defined in [1.2.1], for ships, other than liquefied gas carriers, using ammonia as fuel
- the additional class notation **AMMONIAFUEL-PREPARED**, defined in [1.2.3], for ships prepared to use ammonia as fuel.

1.2 Classification

1.2.1 Ammonia-fuelled ships

Ammonia-fuelled ships, other than liquefied gas carriers, that are designed and built in accordance with the requirements of Chapter 2 are to be assigned the additional class notation **ammoniafuel**.

The additional class notation **ammoniafuel** is completed by:

- the notation **singlefuel** when the ship engines use only ammonia as fuel
- the notation **dualfuel** when the ship engines use ammonia as fuel and fuel oil.

The additional class notations **ammonialfuel dualfuel** or **ammoniafuel singlefuel** may be completed by:

- the notation **-prop** when ammonia fuel is only used for propulsion systems
- the notation **-aux** when ammonia fuel is only used for auxiliary systems.

For ammonia-fuelled ships fitted with fuel cells the additional requirements of [1.2.2] are to be considered.

1.2.2 Ammonia-fuelled ships fitted with fuel cells

In addition to the requirements of [1.2.1], for ammonia-fuelled ships fitted with fuel cells using ammonia as fuel and complying with the requirements of NR547 “Ships using fuel cells”, the additional class notation **fuelcell** is to be assigned to complete the additional class notation **ammoniafuel**.

1.2.3 Ammonia fuel prepared ships

New ships that are designed to accommodate installation of an ammonia fuel system at a later stage and complying with the requirements of Chapter 3 may be assigned the additional class notation **AMMONIAFUEL-PREPARED** completed, as applicable, by notations **S**, **A**, **T**, **H**, **P** or **B**, as defined in Ch 3, Sec 1, [1.1.2].

When the ship is effectively converted to operate on ammonia fuel, the additional class notation **AMMONIAFUEL-PREPARED** is to be replaced by the additional class notation **ammoniafuel dualfuel**, provided that the requirements of Chapter 2 are fulfilled.

1.3 Reference documents

1.3.1 Statutory requirements

This Rule Note includes the requirements, printed in italic type, from IMO Circular MSC.1/Circ.1687 “Interim Guidelines for the safety of ships using ammonia as fuel”, which are applicable for classification purposes.

The correspondence between the references of IMO Circular MSC.1/Circ.1687 and the present Rule Note are provided in Ch 2, App 1.

1.3.2 References to Society’s Rules for Classification and Rule Notes

The following references to BV Rules and Rule Notes are used in this Rule Note:

- NR467 Rules for the classification of steel ships
- NR529 Gas-fuelled Ships.

CHAPTER 2
AMMONIA-FUELLED SHIPS

Section 1 General Requirements for Ammonia-fuelled Ships

1 General

1.1 Principles

1.1.1 Ships complying with the requirement of this Chapter may be assigned the additional class notation **ammoniafuel** as defined in Ch 1, Sec 1, [1.2.1].

1.1.2 Ammonia may be supplied to fuel consumers in liquid or gaseous state.

1.1.3 As a general principle, except where otherwise stated in this Rule Note, ammonia-fuelled ships are to comply with the provisions of NR529 "Gas-fuelled ships".

1.2 Documentation to be submitted

1.2.1 The documentation listed in Tab 1 is to be submitted.

Table 1 : Documentation to be submitted

No.	A/I **(1)**	Documentation	Particulars
1	I	Ammonia installation general arrangement	General arrangement drawing of the ship showing the areas and spaces containing the ammonia installations and piping including: • the ammonia bunkering stations • the ammonia tanks • the ammonia boil-off management systems • the ammonia fuel handling systems • the ammonia valve units • the ammonia release mitigation systems • the vent mast • the inert gas system
2	I	General specification of the ammonia fuel installation	Including: • type and capacity of the ammonia storage tanks, range of pressure and temperature anticipated under operational conditions, including maximum vapour pressure, maximum liquid temperature and other important design conditions • description of the ammonia machinery plant • bunkering method (from terminal, bunker ship or barge, truck) • tank pressure control philosophy and boil-off management principle
3	A	Drawing showing: • the hazardous areas and their classification • the toxic areas	
4	A	Drawing showing the number and location of the emergency showers and eye rinsing equipment	
5	A	Safe haven(s) specification	Including: • location, accesses to, and surface area of, the safe haven(s) • philosophy to minimize the risk of exposure to ammonia • detailed description of the ventilation system and other systems relevant to the safe haven
6	A	Drawing showing the structural fire protection and cofferdams provided in connection with ammonia installations	
(1) A: to be submitted for approval; I: to be submitted for information			

No.	A/I **(1)**	Documentation	Particulars
7	A	Details of fire-extinguishing appliances and systems related to ammonia installation	Water-spray system when required, dry chemical powder, fire main
8	A	Specification and details of the water screens	As required by Sec 2, [3.1.8] in the fuel preparation room and by Sec 2, [3.2.7] for the tank connection space
9	A	Arrangement of accesses to spaces containing a potential source of ammonia release and to hazardous area zones	
10	A	Airlocks between safe and hazardous area zones or spaces containing a potential source of ammonia release	
11	A	Arrangement of the ventilation systems serving the spaces containing a potential source of ammonia release and hazardous area zones	Including ventilation duct arrangement in adjacent zones
12	I	Ventilation capacity calculation for spaces containing a potential source of ammonia leakage	
13	A	Diagram of the bilge systems serving spaces containing a potential source of ammonia release	
14	A	Liquid ammonia drain tank capacity and specification	See Sec 2, [5.3]
15	A	Diagram of drip trays drainage	
16	A	Details of hull structure in way of ammonia fuel tanks	Including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.
17	I	Calculation of the hull temperature in all design conditions	For membrane tanks, type A and type B tanks
18	I	FPR and TCS boundary temperature analysis	As required by Sec 2, [3.1.5] and Sec 2, [3.2.3]
19	A	Distribution of steel grades in relation to the values obtained from the hull temperature calculation	For membrane tanks, type A and type B tanks
20	I	Hull stress analysis	
21	A	Schematic electrical wiring diagram in hazardous areas	
22	A	Arrangement of electrical installation in hazardous areas, including lighting system	
23	A	List of electrical equipment located in hazardous areas	
24	I	Certified safe type documentation for electrical equipment located in hazardous areas	
25	A	Details of electrical bonding of fuel tanks and piping	
26	A	Ammonia detection system	
27	I	Specification of ammonia sensors with performance characteristics and test report	
28	I	Risk assessments and follow-up report of the recommendations	See Article [3]
29	I	Ammonia dispersion analysis	As required by Sec 5, [3.2.3]
30	A	Details of the bunkering safety link or equivalent system	As required by Sec 4, [3.4.4]
31	A	Program of ammonia trials	
32	A	Scantlings, material and arrangement of the fuel containment system	Including the secondary barrier, if any
33	A	Details of insulation of the fuel containment system	
34	A	Details of ladders, fittings, swash bulkheads and towers in tanks and relative stress analysis, if any	
35	A	Details of tank domes and deck sealings	
36	I	Structural analysis for the tank(s) and supports as applicable	
37	I	Hull ship motion analysis	Where a direct analysis is preferred to the methods indicated in NR529, Chapter 3
38	I	Sloshing calculation covering the full range of intended filling levels	For membrane tanks, type A and type B tanks
(1) A: to be submitted for approval; I: to be submitted for information			

No.	A/I **(1)**	Documentation	Particulars
39	A	Interbarrier space drainage, inerting and pressurisation systems if fitted	
40	I	Ammonia containment system gas freeing procedure	Including emptying, inerting and aerating
41	A	Ammonia tank instrumentation	
42	A	Emergency shutdown system	Including ammonia temperature monitoring system
43	A	Ammonia tank filling limits	
44	A	Inspection/survey plan	As requested by NR529, Ch 3, Sec 2, [1.1.8]
45	I	Specification of the boil-off vapour management system(s)	
46	I	Calculations of the boil-off rate of the tank, for the different operating conditions	Including maximum ambient temperature, filling rates, pressure and temperature in the tank after bunkering
47	A	Plans and calculations of tank PRVs	
48	I	Procedure for emergency isolation of a fuel tank PRV in the event of a failure	
49	I	Specification, drawings, calculations and material characteristics of the pumps, compressors and heat exchangers	
50	A	Details of process pressure vessels and relative valving arrangement	
51	A	Schematic diagram and materials of the ammonia (liquid and vapour) piping systems	Including venting systems and vapour return line if fitted
52	A	Plans, arrangement and calculations of safety relief valves	
53	A	Details of the piping secondary enclosure	
54	A	Arrangement of the vent mast	
55	I	Specification of the ammonia release mitigation system	
56	I	Justification of the ammonia release mitigation system capacity	
57	A	Diagram of the fuel oil system including pilot fuel supply	
58	A	Diagram of the engine lubricating oil system	
59	A	Diagram of the engine cooling system	
60	A	Diagram of the engine crankcase venting systems	
61	A	Drawings of the boilers, including burners	
62	A	Drawing of the exhaust gas ducts	
63	A	Specification of the control, monitoring and safety systems for each ammonia utilization unit	
64	A	Instrumentation list	
65	I	Specification and type-approval reference of the ammonia utilization units	
66	A	Diagram of the ammonia fuel supply systems	For each ammonia utilization unit
67	A	Arrangement of the ammonia valve units	
(1) A: to be submitted for approval; I: to be submitted for information			

2 Definitions

2.1 Definitions

2.1.1 Abnormal scenario

Abnormal scenario means an ammonia release scenario resulting from a failure affecting the ammonia fuel system. Events such as fire or flooding need not be considered in the scope of an abnormal scenario.

2.1.2 Ammonia

Ammonia means an inorganic compound represented by the chemical formula NH_3*. In this Rule Note, ammonia either in its liquefied or gaseous state is referred to as ammonia.*

2.1.3 Ammonia release mitigation system (ARMS)

Ammonia release mitigation system (ARMS) means a system intended for reducing the ammonia concentrations released to the atmosphere from operational sources of releases or from other sources of release, including in emergency situations, by means of:

- combustion,
- dissolution in water,
- re-liquefaction, or
- dilution with air.

2.1.4 Direct release

Direct release means that the vapours generated by the source of release are not treated before being released into the atmosphere.

2.1.5 Enclosed space

Enclosed space means any space within which, in the absence of artificial ventilation, the ventilation will be limited, and any explosive and/or toxic atmosphere will not be dispersed naturally.

2.1.6 Fuel

Fuel means ammonia, either in its liquefied or gaseous state.

2.1.7 Fuel consumer

Fuel consumer means any unit using ammonia as a fuel.

2.1.8 Liquid ammonia recovery system

Liquid ammonia recovery system means a system intended for the recovery of liquid ammonia discharged from a source of release and intended to be recycled.

2.1.9 Source of release

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 and/or toxic atmosphere could be formed.

"Sources of release" include sources of operational releases and other sources of release associated with:

- a failure in the ammonia fuel system resulting in a leakage or
- an event, other than a failure, affecting the ammonia fuel system other than the storage tank and resulting in the opening of a pressure relief valve

Parts of the ammonia fuel system that are protected by a secondary enclosure are not considered as sources of release.

2.1.10 Toxic area

"Toxic area" means an area in which ammonia is or may be expected to be present.

2.1.11 Toxic space

Toxic space means an enclosed or semi-enclosed space in which ammonia is or may be expected to be present. A gas safe machinery space is not considered to be a toxic space.

Toxic spaces include enclosed and semi-enclosed spaces containing potential sources of release.

3 Risk assessment

3.1 General

3.1.1 *A holistic risk assessment is to be conducted to ensure that risks arising from the use of ammonia as fuel affecting persons on board, the environment, the structural strength, or the integrity of the ship and its sub-systems are addressed. Consideration is to be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.*

3.1.2 The risks are to be analysed using acceptable and recognized risk analysis techniques, as per IACS Recommendation No.146 "Risk assessment as required by the IGF code". The risk assessment is to include an HAZID study and an HAZOP study.

3.1.3 The analysis is to ensure that risks are as low as reasonably practicable (ALARP).

3.1.4 *Risks which cannot be eliminated are to be mitigated as necessary. Details of risks, and the means by which they are mitigated, are to be documented to the satisfaction of the Society.*

3.2 Hazard to be covered

3.2.1 *The risk assessment is to specifically consider the ammonia system integrity with focus on its ability to prevent and isolate leakages and also evaluate potential toxicity hazards, ignition mechanisms and consequences of ignition. Special consideration is to be given, but not limited to, the following specific ammonia-related hazards and topics:*

a) *Loss of function*
b) *component damage*
c) *fire*
d) *explosion*
e) *toxicity*
f) *electric shock*
g) *collision*
h) *grounding*
i) flooding
j) pollution
k) variations of bunkered ammonia fuel characteristics (temperature).

3.2.2 The risk assessment is to cover the following systems and equipment:

- ammonia bunkering system
- systems intended for maintaining the temperature and pressure in the ammonia storage tank
- ammonia piping system
- ammonia machinery (engines, gas turbines, boilers)
- liquid ammonia recovery system and ammonia release mitigation systems (ARMS).

3.2.3 The risk assessment is to cover at least the following spaces and zones:

- tank hold spaces
- tank connection space (TCS)
- ammonia fuel preparation room
- bunkering stations and bunkering control position
- spaces containing liquid ammonia recovery systems and drain tanks
- ammonia release mitigation system room
- spaces containing liquid or gaseous ammonia piping.

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

- the arrangement of the drip trays, in particular their capacity and draining arrangement
- the accumulation of ammonia vapours in spaces containing a potential source of ammonia release and their spreading over the ship's spaces through non-gastight openings
- the release of ammonia vapours from crankcase and crankcase vent systems for trunk piston engines or from scavenge air spaces of crosshead engines
- the release of ammonia vapours from ammonia pipe enclosures
- the release of ammonia vapours from explosion relief devices
- the release of ammonia vapours to engine auxiliary systems such as cooling water systems
- the spreading of ammonia vapours from the ventilation and venting outlets and their possible recirculation to accommodation through openings and ventilation inlets
- the formation of ammonia vapour cloud in the vicinity of the ship or in remote locations, taking into account the ambient conditions (e.g. humidity)
- the heat release in case of ammonia dissolution in water
- the draining of the hold space in case of type A tank failure.
- the number, location, design and arrangement of the safe havens
- design and location of muster stations and escape routes
- number and location of shower and eyewashes
- design and location of the bunkering control position.

The ammonia spreading scenarios in case of leakage, including ammonia spread through common ventilation ducting, are to be analyzed.

3.2.5 A failure mode, effect, and criticality analysis (FMECA) is to be carried out for the following systems:

- ammonia release mitigation system (ARMS)
- liquid ammonia recovery system
- boil-off management system.

4 Limitation of explosion consequences

4.1 Explosion analysis

4.1.1 *An explosion in any space containing any potential sources of release and potential ignition sources is not to:*

a) *cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs;*

b) *damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;*

c) *damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured;*

d) *damage ship personnel normally present in work or accommodation spaces under normal operating conditions;*

e) *disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution;*

f) *damage life-saving equipment or associated launching arrangements;*

g) *disrupt the proper functioning of fire-fighting equipment located outside the explosion-damaged space;*

h) *affect other areas of the ship in such a way that chain reactions involving, inter alia, cargo, ammonia and bunker oil may arise; or*

i) *prevent persons' access to life-saving appliances or impede escape routes.*

Section 2 Ship Design and Arrangement

1 General provisions

1.1 Management of ammonia releases

1.1.1 *Direct release of ammonia into the atmosphere during normal operation and during any foreseeable and controllable abnormal scenario is to be avoided.*

1.1.2 *The fuel supply system is to be designed so as to avoid direct release of ammonia to the atmosphere during normal operation and during any foreseeable and controllable abnormal scenario.*

1.1.3 *Operational gas releases are to be collected and handled by a suitable ammonia release mitigation system (ARMS).*

1.1.4 Abnormal ammonia releases and emergency releases may be required to be handled by an ARMS as a result of the dispersion analysis required by Sec 5, [3.2.3].

1.1.5 *Fuel containment systems, fuel piping and other fuel sources of release are to be so located and arranged that released ammonia is led to a recovery system, treatment system or a safe location in the open air.*

"Safe location" means that the release of ammonia vapours in such location will not result in fire, explosion, or toxic exposure of the persons on board.

1.1.6 Ammonia release mitigation systems (ARMS) are to comply with the provisions of Sec 5, [3.5].

1.1.7 Except otherwise specified, ammonia vapours may be released directly into the open air when it is demonstrated that the ammonia concentration in the most unfavourable scenario is:

- below 110 ppm at the point of discharge into the atmosphere, in case of operational releases,
- below 220 ppm at the locations mentioned in Sec 5, [3.2.3], in case of abnormal or emergency releases.

1.1.8 Liquid ammonia released from the fuel supply system is to discharge to the fuel tank or to the gas-liquid separator referred to in Sec 4, [4.2.7]. Liquid ammonia spills are to be collected in drip trays connected to the liquid ammonia drain tank referred to in [5.3].

1.2 Location and protection of fuel storage tanks and equipment

1.2.1 *Fuel storage tanks and/or equipment located on open deck are to be located to ensure sufficient natural ventilation to prevent accumulation of ammonia.*

1.2.2 Where the dispersion analysis required by Sec 5, [3.2.3] shows that, in case of leakage from an ammonia equipment located on open deck, ammonia concentrations exceeding the limit recommended by the risk analysis may occur at locations where persons may be present, an enclosure with ammonia liquid recovery and vapour treatment through an ammonia release mitigation system (ARMS) may be required for the equipment.

1.2.3 *Fuel storage tanks are to be protected against mechanical damage.*

1.2.4 *Unless expressly provided otherwise, the provisions for protection of fuel tanks from collision and grounding in NR529, Ch 2, Sec 1, [2.1.4], NR529, Ch 2, Sec 1, [2.1.5] and NR529, Ch 2, Sec 1, [2.1.6] apply to ships using ammonia as fuel.*

1.3 Arrangement of tank connection spaces and tank hold spaces

1.3.1 *Tank connection spaces and fuel storage hold spaces other than for tank type C are to be gastight towards adjacent spaces. These spaces are not to be adjacent to accommodation spaces, service spaces, electrical equipment room and control stations by a single bulkhead or deck.*

"Adjacent" means linear contact and point contact.

1.4 Location and protection of fuel piping

1.4.1 *Fuel pipes and fuel supply system are not to be located less than 800 mm from the ship's side.*

1.4.2 *Fuel piping is not to be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations even though the piping is protected by secondary enclosures.*

1.4.3 *Fuel pipes led through ro-ro spaces, special category spaces and on open decks are to be protected against mechanical damage.*

1.5 Access and openings

1.5.1 *The access or other openings to spaces containing fuel sources of release are to be so arranged that flammable, asphyxiating or toxic gas cannot escape to spaces that are not designed for the presence of such gases taking into account the specific gravity and dispersion characteristics of ammonia gas.*

1.5.2 *Mustering stations and life-saving equipment and access to such stations and equipment are not to be located in toxic areas as specified in Sec 5, [3.2].*

1.5.3 *Air intakes, outlets and other openings into the accommodation, service and machinery spaces, control stations and other non-toxic spaces in the ship are not to be located in toxic areas as specified in Sec 5, [3.2].*

2 Machinery space arrangement

2.1 General

2.1.1 *Machinery spaces containing ammonia fuel systems and/or ammonia fuelled machinery are to be arranged such that the spaces may be considered gas safe under all conditions, normal as well as abnormal conditions, i.e. inherently gas safe.*

2.1.2 *In a gas safe machinery space, a single failure cannot lead to release of fuel gas into the machinery space.*

2.1.3 *A gas safe machinery space may be arranged as a conventional machinery space.*

2.1.4 Ammonia fuel consumers are to be so designed that no leakage from the consumer towards the machinery space can occur in case of any single failure.

2.2 Access

2.2.1 *Access to machinery spaces is not to be arranged from toxic areas or toxic spaces.*

2.3 Fuel piping

2.3.1 *All fuel piping within machinery space boundaries is to be enclosed in a gastight enclosure in accordance with Sec 4, [4.3] and NR 529, Ch 5, Sec 2, [3.1.1].*

3 Arrangement of fuel preparation room, tank connection spaces and fuel bunkering stations

3.1 Fuel preparation rooms

3.1.1 *Fuel process equipment is to be arranged in a fuel preparation room arranged in accordance with provisions in this Rule Note. As an exemption to this provision, vaporizers, heat exchangers and motors for pumps submerged in tanks may also be located in tank connection spaces.*

3.1.2 *When fuel preparation rooms cannot be located on open deck, or accessed from open deck, access is to be provided through an airlock in compliance with [6.2].*

3.1.3 *Fuel preparation rooms are to be designed to safely contain fuel leakages. The fuel preparation room boundaries are to be gastight towards other spaces in the ship.*

3.1.4 *The probable maximum leakage into the fuel preparation room is to be determined based on detail design, detection and shutdown systems.*

The actual response time of the leakage detection system is to be considered.

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

An analysis is to be submitted to evaluate the lowest temperature to which the boundaries of the fuel preparation room will be subjected in connection with the cooling effect due to the evaporation of liquid ammonia.

3.1.6 *The fuel preparation room is to be fitted with ventilation arrangements ensuring that the space can withstand any pressure build up caused by vaporization of the liquefied fuel.*

Alternatively, the fuel preparation room may be protected against excessive pressure build up by a pressure relief device discharging to an ammonia release mitigation system (ARMS).

3.1.7 *The fuel preparation room entrance is to be arranged with a sill height exceeding the liquid level resulting from a calculated maximum leakage but is in no case to be lower than 300mm.*

3.1.8 *Fuel preparation room entrances are to be arranged with water screens having constantly available water supply. The water screen is to be possible to activate from a safe location outside the fuel preparation room toxic zone if an ammonia leak occurs. The water screens are to be arranged on the outside of the fuel preparation room. The arrangement is to include the means to safely manage any ammonia effluent produced in their operation.*

3.1.9 *A leakage in the fuel preparation room is not to render necessary safety functions out of order due to low temperatures caused by evaporation of leaking fuel.*

3.1.10 *Fuel preparation rooms are to be designed to manage any ammonia release for personnel to safely enter.*

The fuel preparation room and the ammonia fuel system inside the room are to be so designed and arranged that the access to the fuel preparation room should not be necessary in normal operational condition of the ship.

3.2 Tank connection spaces

3.2.1 *Fuel tank connections, flanges and tank valves are to be located in a tank connection space arranged in accordance with the provisions in this Rule Note. Apart from fuel process equipment allowed in tank connection spaces as defined in [3.1.1], tank connection spaces and fuel preparation rooms are not to be combined.*

3.2.2 *Tank connection spaces are to be designed to safely contain fuel leakages. The tank connection space boundaries are to be gastight towards other spaces in the ship.*

3.2.3 *The material of the bulkheads of the tank connection space is to have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario.*

An analysis is to be submitted to evaluate the lowest temperature to which the boundaries of the tank connection space will be subjected in connection with the cooling effect due to the evaporation of liquid ammonia.

3.2.4 *The probable maximum leakage into the tank connection space is to be determined based on detail design, detection and shutdown systems.*

The actual response time of the leakage detection system is to be considered.

3.2.5 *Tank connection spaces are to be fitted with ventilation arrangements ensuring that the spaces can withstand any pressure build up caused by vaporization of the liquefied fuel.*

Where required by Sec 3, [2.1.1], the tank connection space may be protected against excessive pressure build up by a pressure relief device discharging to an ammonia release mitigation system (ARMS).

3.2.6 *Tank connection space entrances are to be arranged with a sill height exceeding the liquid level resulting from a calculated maximum leakage but is in no case to be lower than 300mm.*

3.2.7 *Tank connection space entrances are to be arranged with water screens having constantly available water supply. The water screen is to be possible to activate from a safe location outside the tank connection space toxic zone if an ammonia leak occurs. The water screens are to be arranged on the outside of the tank connection spaces. The arrangement is to include the means to safely manage any ammonia effluent produced in their operation.*

3.2.8 *Unless the access to the tank connection space is independent and direct from open deck, it is to be provided through a bolted hatch. The bolted hatch is to be located in a protective entry space of gastight construction with a self-closing gastight door. The access is to be arranged to facilitate the evacuation of an injured person from the tank connection space by personnel wearing breathing apparatus and PPE (Personal Protective Equipment).*

The tank connection space and the ammonia fuel system inside the space are to be so designed and arranged that the access to the tank connection space should not be necessary in normal operational condition of the ship.

3.2.9 *A leakage in the tank connection space is not to render necessary safety functions out of order due to low temperatures caused by evaporation of leaking fuel.*

3.3 Fuel bunkering stations

3.3.1 *The location and arrangement of the bunkering station, including whether open, enclosed, or semi-enclosed, is to be subject to special consideration within the risk assessment. Depending on the arrangement this may include, but is not limited to:*

a) *segregation towards other areas of the ship;*

b) *hazardous and toxic area plans for the ship;*

c) *requirements for forced ventilation;*

d) *requirements for leakage detection;*

e) *safety actions related to leakage detection;*

f) *access to bunkering station from non-hazardous areas through airlocks; and*

g) *monitoring of bunkering station by direct line of sight or closed-circuit television (CCTV).*

In case an open bunkering station is foreseen, the ammonia concentrations, as assessed through the dispersion analysis, are to comply with the provisions of Sec 5, [3.2.3], assuming:

- the probable maximum leakage, to be determined based on detail design, detection and shutdown systems, and
- least favourable dispersion conditions.

The actual response time of the leakage detection system is to be considered.

3.3.2 *Mechanical spray shielding is to be arranged around potential leakage sources from the ammonia system in the bunkering station.*

3.3.3 *The bunker station is to be located in an area where sufficient space for efficient work and access is ensured for the personnel involved in bunkering and their equipment while wearing SCBA* (Self-Contained Breathing Apparatus) *and PPE* (Personal Protective Equipment)*, and to ensure that, in an emergency, they have a clear escape route.*

In addition, the ammonia bunkering station and the ammonia bunkering system are to be so designed and arranged that the access for bunkering operations is necessary only for:

- connecting the ammonia transfer hose before starting the bunkering operation
- disconnecting the ammonia transfer hose upon completion of the bunkering operation, after draining and purging of the bunkering pipe.

4 Bilge systems

4.1 General

4.1.1 *Bilge systems installed in areas where* ammonia *fuel can be present are to be segregated from the bilge system of spaces where* ammonia *fuel cannot be present.*

The bilge lines serving a space where ammonia fuel may be present are not to be connected to pumps located in spaces where ammonia fuel cannot be present.

4.2 Draining of holds, insulation spaces and interbarrier spaces

4.2.1 *Where fuel is carried in a fuel containment system requiring a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through the adjacent ship structure are to be provided. The bilge system is not to lead to pumps in spaces having no risks of ammonia. Means of detecting such leakage are to be provided.*

Note 1: “Spaces having no risk of ammonia” means spaces that do not contain any source of release.

4.2.2 *The hold or interbarrier spaces of type A independent tanks for liquid gas are to be provided with a drainage system suitable for handling liquid fuel in the event of fuel tank leakage or rupture.*

The draining system for handling liquid ammonia need not be permanently installed.

4.3 Draining of water screen or water spray systems

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

4.4 Bilge water holding tanks

4.4.1 Bilge water holding tanks dedicated to receiving bilge water from spaces containing a potential source of ammonia release are to be provided. The oily bilge water holding tank may be used for such purpose if it complies with the provisions of [4.4.2] and [4.4.3]. Means for discharging the tanks to reception or treatment facilities are to be provided.

4.4.2 Bilge water holding tanks likely to contain dissolved ammonia are to be located outside the machinery spaces. Such bilge water holding tanks are to be provided with a vent pipe and with means for ammonia vapour detection. They are to be made of a corrosion-resistant material suitable for contact with ammonia. The vent pipe outlet is to be located at least 10 m from the nearest air intake, air outlet or opening to accommodation, service and control spaces, or other non-toxic areas.

4.4.3 Bilge water holding tanks likely to contain dissolved ammonia are to be surrounded by cofferdams, except on those surfaces bound by the ammonia fuel preparation room.

5 Drip trays

5.1 General

5.1.1 *Drip trays are to be fitted where leakage may occur which can cause damage to the ship structure or where limitation of the area which is affected from a spill is necessary.*

Drip trays are to be fitted in areas where spills may occur, in particular:

- at the bunkering station, in way of the bunkering connections
- in ammonia fuel preparation rooms and tank connection spaces, in way of possible liquid fuel leakage sources including detachable pipe connections, pumps, valves and heat exchangers.

5.2 Design and arrangement of drip trays

5.2.1 *Drip trays are to be made of suitable material.*

5.2.2 *The drip trays are to be thermally insulated from the ship's structure so that the surrounding hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid fuel.*

5.2.3 *Each tray is to be fitted with a drain valve to enable water to be drained over the ship's side where the tray is installed in a location where water may be retained.*

5.2.4 *Each tray is to have a sufficient capacity to ensure that the assumed maximum amount of spill according to the risk assessment can be handled,* taking into account the draining system required in [5.2.5] and [5.2.6].

5.2.5 *Drip trays are to be provided with means to safely drain or transfer spills that contain ammonia to be contained or treated.*

5.2.6 Drip trays intended to collect liquid ammonia are to be fitted with a draining system arranged for automatic activation in case of leakage detection and discharging to the liquid ammonia drain tank referred to in [5.3]. Arrangements are to be made to prevent vapour backflow through the drain pipe.

5.3 Liquid ammonia drain tank

5.3.1 A liquid ammonia drain tank is to be provided to contain liquid ammonia collected from drip trays and pipe enclosures in case of leakage. Its capacity is to be based on the worst leakage scenario.

5.3.2 The tank is to be located outside machinery spaces and is to be surrounded by cofferdams.

5.3.3 The vent pipe from the drain tank is to be led to an ARMS and is to be provided with a secondary enclosure complying with Sec 4, [4.3].

5.3.4 The drain tank is to be designed to withstand the pressure build up and cooling effect due to liquid ammonia evaporation. The following information are to be provided and justified:

- maximum pressure in the tank
- minimum temperature in the tank
- vapour flowrate in the tank venting system
- ammonia vapour concentration in the tank.

5.3.5 The drain tank is to be fitted with a level gauge designed to prevent any ammonia release.

6 Entrances, openings and airlocks

6.1 Arrangement of entrances and other openings in enclosed spaces

6.1.1 *Direct access is not to be permitted from a non-hazardous area to a hazardous area. Where such openings are necessary for operational reasons, an airlock which complies with [6.2] is to be provided.*

6.1.2 *Direct access is not to be permitted from a non-toxic space to a toxic area or space. Where such openings are necessary for operational reasons, an airlock which complies with [6.2] is to be provided.*

6.1.3 *For inerted spaces access arrangements is to be such that unintended entry by personnel should be prevented. If access to such spaces is not from an open deck, sealing arrangements are to ensure that leakages of inert gas to adjacent spaces are prevented.*

6.1.4 *Arrangements for fuel storage hold spaces, void space, fuel tanks and other spaces classified as hazardous/toxic areas or spaces, are to be such as to allow entry and inspection of any such space by ship personnel wearing PPE (Personal Protective Equipment) and breathing apparatus as well as to allow for the evacuation of injured or unconscious ship personnel. Such arrangements are to comply with the following:*

a) *Access is to be provided as follows:*
   1) *access to all fuel tanks. Access is to be directly from open decks as far as practicable;*
   2) *access through horizontal openings, hatches or manholes. The size is to be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction, and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening is to be not less than 600 mm × 600 mm;*
   3) *access through vertical openings or manholes providing passage through the length and breadth of the space. The minimum clear opening is to be not less than 600 mm x 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided; and*
   4) *circular access openings to type C tanks are to have a diameter of not less than 600 mm.*

b) *The sizes referred to in items a) 2) and a) 3) may be decreased, if [6.1.4] can be met to the satisfaction of the Society.*

c) *Where fuel is carried in containment systems requiring secondary barriers, the requirements of items a) 2) and a) 3) do not apply to spaces separated from hold spaces by a single gastight steel boundary. Such spaces are to be provided only with direct or indirect access from open decks, excluding any enclosed non-hazardous areas.*

6.1.5 Toxic spaces are to be provided with locking arrangements. A warning notice with safety instructions for access to the space is to be provided outside the space, adjacent to the access door or hatch.

6.2 Airlocks

6.2.1 *An airlock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1,5 m and not more than 2,5 m apart. Unless subject to the requirements of the International Convention on Load Lines, the door sill is not to be less than 300 mm in height. The doors are to be self-closing without any holding back arrangements.*

6.2.2 *Airlocks are to be mechanically ventilated at an overpressure relative to the adjacent hazardous/toxic area or space.*

6.2.3 *The airlock is to be designed in a way that no gas can be released to safe spaces in case of the most critical event in the hazardous/toxic space separated by the airlock. The events are to be evaluated in the risk analysis according to Sec 1, [3].*

6.2.4 *Airlocks are to have a simple geometrical form. They are to provide free and easy passage and are to have a deck area not less than 1,5 m^2. Airlocks are not to be used for other purposes, for instance as storerooms.*

6.2.5 *An audible and visual alarm system to give a warning on both sides of the airlock is to be provided to indicate if more than one door is moved from the closed position.*

6.2.6 *For non-hazardous/non-toxic spaces with access from hazardous/toxic spaces below deck where the access is protected by an airlock, upon loss of under pressure in the hazardous/toxic space, access to the space is to be restricted until the ventilation has been reinstated. Audible and visual alarms are to be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.*

Section 3 Fuel Containment System

1 General

1.1 Compliance with NR529

1.1.1 *Unless expressly provided otherwise, the requirements of NR529 Ch 3, Sec 2 apply to ships using ammonia as fuel.*

1.1.2 *The provision of NR529 Ch 3, Sec 2 [1.1.3] related to portable tanks are not to apply to ships using ammonia as fuel.*

1.2 Ammonia fuel storage conditions

1.2.1 *The ammonia fuel is to be stored in a refrigerated state at atmospheric pressure.*

1.3 Thermal insulation

1.3.1 Thermal insulation is to be provided as required to limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in [4.1].

1.4 Piping connected to fuel storage tanks

1.4.1 *Pipe connections to the fuel storage tank are to be mounted above the highest liquid level in the tanks, except for type C fuel storage tanks. Connections below the highest liquid level may however also be accepted for other tank types after special consideration by the Society.*

1.4.2 *Piping between the tank and the first valve which release liquid in case of pipe failure is to have safety equivalent to a type C tank, with dynamic stress not exceeding the values given in NR529 Ch 3, Sec 2 [16.3.1].*

1.4.3 *If piping is connected below the liquid level of the tank it has to be protected by a secondary barrier up to the first valve.*

1.4.4 For type C tanks, the secondary barrier required in [1.4.3] is to consist of an external piping continuously enclosing the inner liquid pipe from the tank inner wall to the first valve body. The external pipe is to be provided with a draining system complying with Sec 4, [4.3.8] and with a leakage detection system complying with Sec 4, [4.3.7].

1.5 Tank emptying, purging and venting

1.5.1 *Means are to be provided whereby liquefied gas in the storage tanks can be safely emptied.*

1.5.2 *Arrangements are to be made to empty, purge and vent fuel storage tanks with fuel piping systems. They are to comply with the provisions of NR529 Ch 3, Sec 8.*

1.5.3 Ammonia vapours released during tank purging, inerting and venting operations are to be handled by an ARMS, except where planned to be treated by the bunkering facility or by an ammonia vapour treatment onshore facility, or where permitted by Sec 2, [1.1.7].

Note 1: Tank purging, inerting and venting are not regarded as normal operations.

1.6 Tank supporting

1.6.1 Contacts of tanks to supporting blocks are to be checked on board.

2 Pressure relief system

2.1 General

2.1.1 *All fuel storage tanks are to be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces and tank connection spaces, which may be subject to pressures beyond their design capabilities, are also to be provided with a suitable pressure relief system. Pressure control systems specified in [4] are to be independent of the pressure relief systems.*

2.1.2 *Fuel storage tanks which may be subject to external pressures above their design pressure are to be fitted with vacuum protection systems.*

2.2 Pressure relief systems for liquefied ammonia fuel tanks

2.2.1 *Liquefied ammonia fuel tanks are to be fitted with a minimum of two pressure relief valves (PRVs) allowing for disconnection of one PRV in case of malfunction or leakage.*

2.2.2 *Interbarrier spaces are to be provided with pressure relief devices complying with NR 467, Pt D, Ch 9, Sec 8, [2.1.3] and [2.1.4]. For membrane systems, the designer is to demonstrate adequate sizing of interbarrier space PRVs.*

2.2.3 *The opening pressure of the pressure relief valves (PRVs) is not to be higher than the vapour pressure that has been used in the design of the tank. Valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.*

2.2.4 *The following temperature provisions apply to PRVs fitted to pressure relief systems:*

a) *PRVs on fuel tanks with a design temperature below 0°C are to be designed and arranged to prevent their becoming inoperative due to ice formation;*
b) *the effects of ice formation due to ambient temperatures are to be considered in the construction and arrangement of PRVs;*
c) *PRVs are to be constructed of materials with a melting point above 925°C. Lower melting point materials for internal parts and seals may be accepted provided that fail-safe operation of the PRV is not compromised; and*
d) *sensing and exhaust lines on pilot operated relief valves are to be of suitably robust construction to prevent damage.*

2.2.5 *In the event of a failure of a fuel tank PRV, a safe means of emergency isolation is to be available, as follows:*

a) *procedures are to be provided and included in the operation manual;*
b) *the procedures are to allow only one of the installed PRVs for the liquefied gas fuel tanks to be isolated, physical interlocks are to be included to this effect.*

2.2.6 *Each pressure relief valve installed on a liquefied ammonia fuel tank is to be connected to a venting system, which is to be:*

a) *so constructed that the discharge will be unimpeded and normally be directed vertically upwards at the exit;*
b) *arranged to minimize the possibility of water or snow entering the vent system; and*
c) *arranged such that the height of vent exits is not less than B/3 or 6 m, whichever is the greater, above the weather deck and 6 m above working areas and walkways. However, the height of the vent mast, where provided, could be limited to lower value according to special consideration by the Society.*

2.2.7 *The outlet from the pressure relief valves is normally to be located at least B (greatest moulded breadth) or 25 m, whichever is less, from the nearest:*

a) *air intake, air outlet or opening to accommodation, service and control spaces, or other non-hazardous area; and*
b) *exhaust outlet from machinery installations.*

Higher distances may be required, depending on the results of the dispersion analysis. See Sec 5, [3.2.3] and Sec 5, [3.2.7].

2.2.8 *All other fuel gas vent outlets are also to be arranged in accordance with [2.2.6] and [2.2.7]. Means are to be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.*

2.2.9 *In the vent piping system, means for draining liquid from places where it may accumulate are to be provided. The PRVs and piping are to be arranged so that liquid can, under no circumstances, accumulate in or near the PRVs.*

Liquid ammonia is to be drained to the liquid ammonia drain tank required in Sec 2, [5.3].

2.2.10 *Suitable protection screens of not more than 13 mm square mesh are to be fitted on vent outlets to prevent the ingress of foreign objects without adversely affecting the flow.*

2.2.11 *All vent piping is to be designed and arranged not to be damaged by the temperature variations to which it may be exposed, forces due to flow or the ship's motions.*

2.2.12 *PRVs are to be connected to the highest part of the fuel tank. PRVs are to be positioned on the fuel tank so that they will remain in the vapour phase at the filling limit (FL) as given in [3], under conditions of 15° list and 0,015L trim, where L is defined in NR 529 Ch 1, Sec 1 [5.1.32].*

2.3 Sizing of pressure relieving valves

2.3.1 *PRVs are to have a combined relieving capacity for each liquefied gas fuel tank to discharge the greater of the following, with not more than a 20% rise in liquefied gas fuel tank pressure above the MARVS:*

a) *the maximum capacity of the liquefied gas fuel tank inerting system if the maximum attainable working pressure of the liquefied gas fuel tank inerting system exceeds the MARVS of the liquefied gas fuel tanks; or*
b) *vapours generated under fire exposure computed using the following formula:*

$$Q = F\,G\,A^{0,82}$$

where:

Q : *minimum required rate of discharge of air, in m³/s, at standard conditions of 273,15 Kelvin (K) and 0,1013 MPa*

F : *fire exposure factor for different liquefied gas fuel tank types:*

F = 1,0 for tanks without insulation located on deck;

F = 0,5 for tanks above the deck when insulation is approved by the Society. (Approval will be based on the use of a fireproofing material, the thermal conductance of insulation, and its stability under fire exposure);

F = 0,5 for uninsulated independent tanks installed in holds;

F = 0,2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

F = 0,1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds); and

F = 0,1 for membrane tanks;

G : *gas factor according to formula:*

$$G = \frac{12,4}{LD}\sqrt{\frac{ZT}{M}}$$

where:

T : *temperature in Kelvin at relieving conditions, i.e. 120% of the pressure at which the pressure relief valve is set;*

L : *latent heat of the material being vaporized at relieving conditions, in kJ/kg;*

D : *a constant based on ratio of specific heats k and is calculated as follows*

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

where

k : *ratio of specific heats at relieving conditions, and the value of which is between 1,0 and 2,2*

If k is not known, D = 0,606 is to be used

Z : *compressibility factor of the gas at relieving conditions;*

if not known, Z = 1.0 is to be used;

M : *molecular mass of the product.*

The gas factor of each liquefied gas fuel to be carried is to be determined and the highest value is to be used for PRV sizing.

A : *external surface area of the tank, in m², as for different tank types, as shown in Fig 1.*

2.3.2 *For tanks in fuel storage hold spaces separated from potential fire loads by cofferdams or surrounded by ship spaces with no fire load the following is to apply:*

If the pressure relief valves have to be sized for fire loads the fire factors may be reduced to the following values:

F = 0,5 to F = 0,25

F = 0,2 to F = 0,1

2.3.3 *The required mass flow of air M_{air}, in kg/s, at relieving conditions is given by:*

$$M_{air} = Q\,\rho_{air}$$

where:

ρ_{air} : *density of air equal to 1,293 kg/m³ (air at 273,15 K and 0,1013 MPa).*

2.4 Sizing of vent pipe system

2.4.1 *Pressure losses upstream and downstream of the PRVs, are to be taken into account when determining their size to ensure the flow capacity required by [2.3].*

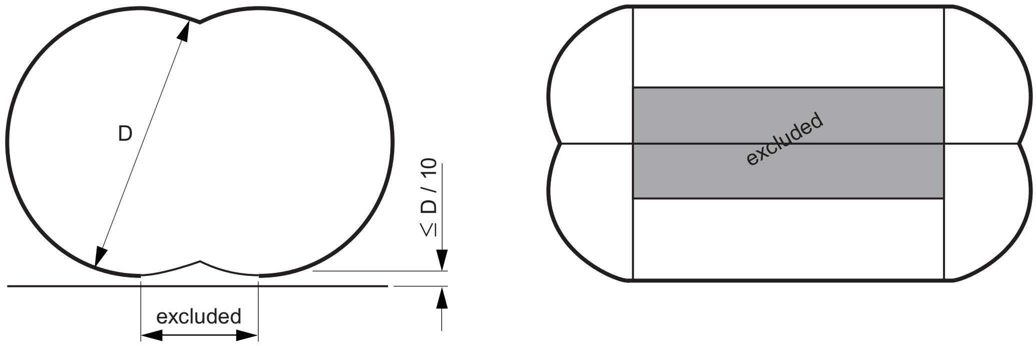
2.4.2 *With regard to upstream pressure losses:*

a) *the pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3% of the valve set pressure at the calculated flow rate, in accordance with [2.3];*

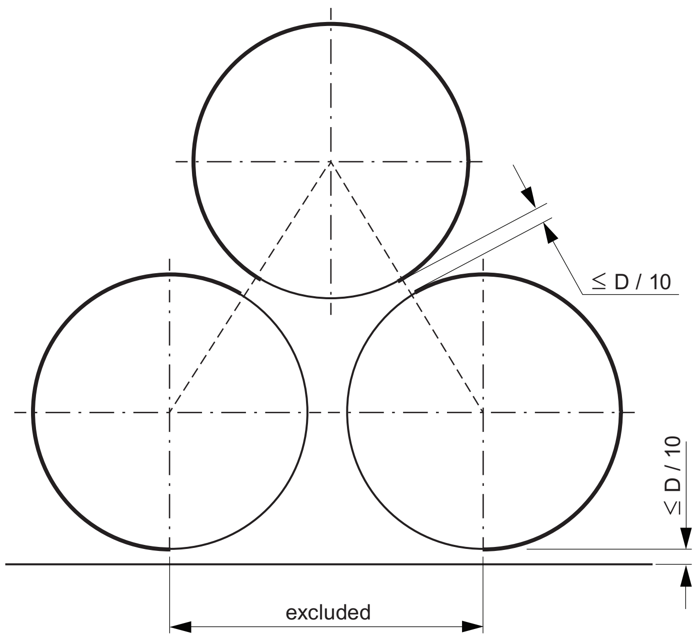
b) *pilot operated PRVs is to be unaffected by inlet pipe pressure losses when the pilot senses directly from the tank dome; and*

c) *pressure losses in remotely sensed pilot lines are to be considered for flowing type pilots.*

Figure 1 : External surface area of the tanks



Bilobe tanks



Horizontal cylindrical tanks arrangement

2.4.3 *With regard to downstream pressure losses:*

a) *Where common vent headers and vent masts are fitted, calculations are to include flow from all attached PRVs.*

b) *The built-up back pressure in the vent piping from the PRV outlet to the location of discharge to the atmosphere, and including any vent pipe interconnections that join other tanks, is not to exceed the following values:*

- *for unbalanced PRVs:*

  10% of MARVS;

- *for balanced PRVs:*

  30% of MARVS; and

- *for pilot operated PRVs:*

  50% of MARVS.

Alternative values provided by the PRV manufacturer may be accepted.

2.4.4 *To ensure stable PRV operation, the blow-down is not to be less than the sum of the inlet pressure loss and 0.02 MARVS at the rated capacity.*

3 Loading limit

3.1 Ammonia fuel tanks

3.1.1 *Storage tanks for liquefied ammonia are not to be filled to more than a volume equivalent to 98% full at the reference temperature as defined in NR 529, Ch 1, Sec 1, [3.1.43].*

A loading limit curve for actual fuel loading temperatures is to be prepared from the following formula:

$$LL = FL\frac{\rho_R}{\rho_L}$$

where:

LL : *loading limit as defined in NR 529, Ch 1, Sec 1, [3.1.34], expressed in per cent;*

FL : *filling limit as defined in NR 529, Ch 1, Sec 1, [3.1.16], expressed in per cent, here 98%;*

ρ_R : *relative density of fuel at the reference temperature; and*

ρ_L : *relative density of fuel at the loading temperature.*

3.1.2 *In cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95%.*

4 Means of maintaining fuel storage condition

4.1 Control of fuel temperature and tank pressure

4.1.1 *The fuel tanks are to be designed to maintain the liquefied ammonia in the tanks at a temperature of no more than -30°C at all times by means acceptable to the Society. Systems and arrangements to be used for this purpose may include one, or a combination of, the following methods:*

a) reliquefaction of vapours;

b) thermal oxidation of vapours; or

c) liquefied ammonia fuel cooling.

The method chosen is to be capable of maintaining the fuel temperature assuming no consumption for propulsion or power generation.

4.1.2 *Venting of fuel vapour for control of the tank pressure is not acceptable except in emergency situations. S*ee also Sec 2, [1.1.7].

4.1.3 Where no vapour return line is fitted, the boil-off vapour management system is to be designed to handle the maximum boil-off vapour rate expected during bunkering operations.

4.2 Design of systems

4.2.1 *For worldwide service, the upper ambient design temperature is to be sea 32°C and air 45°C. For service in particularly hot or cold zones, these design temperatures are to be increased or decreased, to the satisfaction of the Society.*

4.2.2 *The overall capacity of the system is to be such that it can control the temperature and pressure within the design conditions without venting to atmosphere.*

4.3 Reliquefaction systems

4.3.1 *The reliquefaction system is to be arranged in one of the following ways:*

a) a direct system where evaporated fuel is compressed, condensed, and returned to the fuel tanks;

b) an indirect system where fuel or evaporated fuel is cooled or condensed by refrigerant without being compressed;

c) a combined system where evaporated fuel is compressed and condensed in a fuel/refrigerant heat exchanger and returned to the fuel tanks; or

d) if the reliquefaction system produces a waste stream containing ammonia during pressure control operations within the design conditions, these waste gases are to be disposed of without venting to atmosphere.

Waste gases from reliquefaction systems are considered as operational ammonia releases. They are to be led to an ARMS, except where permitted by Sec 2, [1.1.7].

4.4 Thermal oxidation systems

4.4.1 *Thermal oxidation can be done by either consumption of the vapours according to the provisions for fuel consumers described in this Rule Note or in a dedicated gas combustion unit (GCU). It is to be demonstrated that the capacity of the oxidation system is sufficient to consume the required quantity of vapours.*

4.5 Compatibility

4.5.1 *Refrigerants or auxiliary agents used for refrigeration or 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.*

4.6 Availability of systems

4.6.1 *The availability of the system and its supporting auxiliary services is to be such that in case of a single failure (of mechanical non-static component or a component of the control systems) the fuel tank pressure and temperature can be maintained by another service/system.*

4.6.2 A failure mode, effect, and criticality analysis (FMECA) is to be carried out to:

- assess whether another system for controlling the fuel temperature and tank pressure needs to be installed (stand-by system) or,
- identify which supporting auxiliary services need to be redundant.

4.6.3 *Heat exchangers that are solely necessary for maintaining the pressure and temperature of the fuel tanks within their design ranges are to have a standby heat exchanger unless they have a capacity in excess of 25% of the largest required capacity for pressure control and they can be repaired on board without external sources.*

Section 4 Materials, Machinery and Piping Systems

1 Materials

1.1 Ammonia containment and piping systems

1.1.1 *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 items a) to f) below are to be taken, as appropriate.*

a) *Where carbon-manganese steel is used, fuel tanks, process pressure vessels and fuel piping are to be made of fine-grained steel with a specified minimum yield strength not exceeding 355 N/mm², and with an actual yield strength not exceeding 440 N/mm². One of the following constructional or operational measures is also to be taken:*
   1) *lower strength material with a specified minimum tensile strength not exceeding 410 N/mm² is to be used; or*
   2) *fuel tanks, etc., are to be post-weld stress relief heat treated; or*
   3) means are to be provided to maintain storage *temperature, 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*
   4) *the ammonia is to contain not less than 0.1% w/w water, and the master is to be provided with documentation confirming this.*

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

c) *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 carbon-manganese steel or nickel steel.*

d) *The tensile and yield properties of the welding consumables are to 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 in items a) and b), are particularly susceptible to ammonia stress corrosion cracking and are not to be used in containment and piping systems for the storage of this product.*

f) *Nickel steel containing not more than 5% nickel may be used, provided the storage temperature complies with the requirements specified in item a) 3).*

1.1.2 Copper, copper-bearing alloys and zinc are not to be used in pipelines, valves, fittings and other items of equipment in contact with ammonia.

2 General pipe design

2.1 Design pressure

2.1.1 *Fuel piping systems for liquid ammonia are to have as a minimum a design pressure of 18 bar, corresponding to the vapour pressure of ammonia at 45°C, in order to prevent venting of ammonia in idle conditions. Fuel piping systems for gaseous ammonia are to have, as a minimum, a design pressure of 10 bar. For fuel piping systems for liquid ammonia fitted with closed loop pressure relief arrangements routed back to the fuel storage tank, the minimum design pressure is to be10 bar.*

2.2 Use of expansion joints and flexible hoses

2.2.1 *Expansion joints and bellows are not to be used in ammonia fuel piping systems. Engine mounted expansion bellows could be accepted based on evaluation as reflected in the safety concept of the engine.*

2.2.2 If expansion bellows or flexible hoses are used, they are to be of double wall arrangement and type-approved in accordance with the relevant provisions of NR 467, Pt C, Ch 1, Sec 10.

3 Bunkering

3.1 Bunkering station

3.1.1 *Enclosed or semi-enclosed bunkering stations are to be gastight towards adjacent spaces. The term "adjacent" includes linear contact and point contact.*

3.1.2 *Air intakes and openings in accommodation spaces, service spaces, engine rooms and control stations are not to be located in hazardous and toxic areas associated with bunkering stations.*

3.1.3 *Connections and piping are to be so positioned and arranged that any damage to the bunkering piping does not cause damage to the ship's fuel containment system resulting in an uncontrolled fuel discharge.*

3.1.4 *Bunkering piping is not to be led through accommodation spaces, service spaces, electrical equipment rooms or control stations. Where bunkering piping is arranged in other enclosed spaces, bunkering piping is to pass through a secondary enclosure meeting the requirements of [4.3].*

Bunkering piping is to be protected by a secondary enclosure complying with [4.3] throughout its length except within the tank connection space (see [4.3.2]) and within bunkering stations.

Mechanical spray shielding is to be arranged in accordance with Sec 2, [3.3.2].

3.1.5 *Arrangements are to be made for safe management of any spilled fuel.*

Spilled fuel is to be collected in drip trays complying with Sec 2, [5.2].

3.1.6 *Suitable means are to be provided to relieve the pressure and remove ammonia contents from pump suctions and bunker lines. Ammonia is to be discharged to the fuel tanks or other suitable location.*

3.1.7 *The surrounding hull or deck structures are not to be exposed to unacceptable cooling, in case of leakage of fuel.*

3.2 Ships' fuel hoses

3.2.1 *Liquid and vapour hoses used for fuel transfer are to be compatible with the fuel and suitable for the fuel temperature.*

3.2.2 *Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, are to be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering.*

3.2.3 *Where fuel hoses are stored on the open deck or in a storage room, arrangements are to be made for safe storage of the hoses.*

3.3 Manifold

3.3.1 *The bunkering manifold is to be designed to withstand the external loads during bunkering. The connections at the bunkering station are to be arranged in order to achieve a dry-disconnect operation in one of the followings ways:*

a) *a dry-disconnect / connect coupling; or*

b) *a manual connect coupler or hydraulic connect coupler, used to connect the bunker system to the receiving vessel bunkering manifold presentation flange; or*

c) *a bolted flange to flange assembly.*

3.3.2 *When intended to use either of the connections specified in [3.3.1], items b) and c), these are to be combined with operating procedures that ensure a dry-disconnect is achieved. The arrangement is to be subject to special consideration informed by a bunkering arrangement risk assessment conducted at the design stage and considering dynamic loads at the bunkering manifold connection, the safe operation of the ship and other hazards that may be relevant to the ship during bunkering operation.*

3.3.3 *An emergency release coupler (ERC) / Emergency Release System (ERS) or equivalent means is to be provided, unless installed on the bunkering supply side of the bunkering line; it is to enable a quick physical disconnection "dry break-away" of the bunker system in an emergency event.*

3.4 Bunkering system

3.4.1 *An arrangement for purging fuel bunkering lines with inert gas is to be provided.*

Ammonia vapours generated during the purging operation of the bunkering lines are to be led to the fuel storage tank, to the ARMS or to the bunkering facility through the vapour return line, where fitted.

3.4.2 *The bunkering system is to be so arranged that no gas is discharged to the atmosphere during filling of storage tanks. Vapour return line, where fitted, is to be sized adequately taking into consideration the expansion ratio of the fuel during bunkering operations.*

3.4.3 *A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve are to be fitted in every bunkering line close to the connecting point. It is to be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.*

3.4.4 *A bunkering-safety link (BSL), or an equivalent means for automatic and manual ESD communication to the bunkering source, is to be fitted.*

3.4.5 *Means are to be provided for draining any fuel from the bunkering pipes upon completion of operation.*

Liquid ammonia drained from the bunkering pipes is to discharge to the bunkering facility, to the ammonia fuel tank or to the gas-liquid separator referred to in [4.2.7].

3.4.6 *Bunkering lines are to be arranged for inerting and gas freeing. Means to confirm the absence of residual liquid are to be provided.*

3.4.7 *In case bunkering lines are arranged with a cross-over, it is to be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.*

3.4.8 *If not demonstrated to be required at a higher value due to pressure surge considerations a default time as calculated in accordance with NR 529, Ch 9, Sec 1 [7.3.9] from the trigger of the alarm to full closure of the remote operated valve required by [3.4.3] is to be adjusted.*

3.4.9 *Sampling valves, if fitted, are to be arranged at suitable locations in the bunkering line to allow verification procedures to confirm that the bunkering line is safe before opening any flanges. A double shut-off, blank flange or plug is to be installed on sampling valves in the bunkering line.*

4 Fuel supply to consumers

4.1 Redundancy of fuel supply

4.1.1 *For single fuel installations the fuel supply system is to be arranged with full redundancy and segregation all the way from the fuel tanks to the fuel consumer, so that a leakage in one system does not lead to an unacceptable loss of power.*

4.1.2 *For single fuel installations, the fuel storage is to be divided between two or more tanks. The tanks are to be located in separate compartments.*

4.1.3 *For type C tank only, one tank may be accepted if two completely separate tank connection spaces are installed for the one tank.*

4.2 Safety functions of fuel supply system

4.2.1 *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 Sec 6, [1.1.2] is activated.*

Note 1: Normal operation in this context is when fuel is supplied to fuel consumers and during bunkering operations.

4.2.2 *The main fuel supply line and return lines to each fuel consumer or set of consumers are 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 fuel consumers and placed as near as possible to the installation for heating the fuel, if fitted. The master fuel valve is to automatically cut off the fuel supply when activated by the safety system required in Sec 6, [1.1.2].*

4.2.3 *The automatic master fuel valve is to be operable from safe locations on escape routes inside a machinery space containing a fuel consumer, the engine control room, if applicable; outside the machinery space, and from the navigation bridge.*

4.2.4 *The fuel supply lines to fuel preparation rooms are to be equipped with automatically operated shut-off valves situated at the bulkhead inside the fuel preparation room.*

4.2.5 *Each fuel consumer is to be provided with "double block and bleed" valves arrangement. These valves are to be arranged as outlined in a) or b) so that when the safety system required in Sec 6, [1.1.2] is activated this will cause the shutoff valves that are in series to close automatically and the bleed valve to open automatically and:*

a) *the two shutoff valves are to be in series in the fuel pipe to the fuel consuming equipment. The bleed valve is to be in a pipe that vents to a suitable ammonia release mitigation system that portion of the fuel piping that is between the two 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 fuel utilization unit will be blocked and the ventilation opened.*

Venting to ammonia release mitigation system as per clause a) applies only to gaseous ammonia fuel. For liquid ammonia fuel, refer to [4.2.7].

4.2.6 *The two valves are to be of the fail-to-close type, while the ventilation valve is to be fail-to-open.*

4.2.7 *Where fuel supply systems supply ammonia in the liquid state, relevant bleed lines and vent lines are to be led to the fuel tank or gas-liquid separator or similar device to prevent ammonia liquid from being released to the atmosphere.*

Ammonia vapours from the gas-liquid separator (knock-out drum) are considered as operational ammonia releases. They are to be led to the ARMS, except where permitted by Sec 2, [1.1.7].

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

4.2.9 *In cases where the master fuel valve is automatically shutdown when the safety system as required in Sec 6, [1.1.2] is activated, the complete fuel supply branch downstream of the double block and bleed valve is to be automatically purged through the ammonia release mitigation system.*

Note 1: This requirement applies only to gaseous ammonia releases. Liquid ammonia purged from the fuel supply system is to discharge to the fuel tank or to the gas-liquid separator, see [4.2.7].

4.2.10 *There is to be one manually operated shutdown valve in the fuel supply line to each engine upstream of the double block and bleed valves to assure safe isolation during maintenance on the engine. Where fuel is recirculated from each engine to the fuel supply piping, one manually operated shutoff valve is also to be provided downstream of the double block bleed valve in the fuel return piping for each engine.*

4.2.11 *For single-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master fuel valve and the double block and bleed valve functions can be combined.*

4.2.12 *Where gaseous ammonia fuel is supplied to a consumer, provisions are to be made to prevent ammonia condensate from entering the consumer.*

4.3 Fuel piping arrangement

4.3.1 *Fuel pipes are to be protected by a secondary enclosure. This enclosure can be a duct or a double wall piping system.*

4.3.2 *The provision in [4.3.1] need not to be applied for fuel pipes located in a fuel preparation room or tank connection space.*

4.3.3 *The provision in [4.3.1] also applies for fuel vent pipes, except for open-ended fully welded fuel vent pipes in open air.*

4.3.4 The secondary enclosure is to fulfil one of the following conditions:

- it is to be maintained at a pressure lower than that in the adjacent space by means of a mechanical extraction ventilation system. *The duct or double wall piping system is to be fitted with gas detection as required in Sec 6, [5]; or*
- it is to be pressurized with inert gas at a pressure greater than the gas fuel pressure and fitted with an alarm to indicate a loss of inert gas pressure between the pipes.

The enclosure is to be arranged in accordance with the relevant provisions of NR529, Ch 5, Sec 2 [2] and NR529, Ch 5, Sec 2 [3.1] apply.

Other solutions providing an equivalent safety level may also be accepted by the Society.

4.3.5 Ammonia vapours released into engine secondary enclosures during normal operation are to be led to an ARMS except where permitted by Sec 2, [1.1.7]. Ammonia vapours released into engine secondary enclosures in case of failure of the inner pipe may be led to the atmosphere in accordance with Sec 5, [3.2.3].

4.3.6 The secondary enclosure is to be able to withstand the maximum pressure that may build up in the enclosure in case of leakage from the ammonia fuel piping. For this purpose, the secondary enclosure may need to be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressure. The pressure relief system discharge is to comply with [4.3.5].

4.3.7 *Where gas detection as required in Sec 6, [5.2.1] item b) is not fit for purpose, the secondary enclosures around liquefied fuel pipes are to be provided with leakage detection by means of pressure or temperature monitoring systems, or any combination thereof.*

4.3.8 For liquid ammonia fuel pipes, the secondary enclosure is to be provided with a leakage detection system complying with [4.3.7] and a draining system arranged for automatic activation in case of leakage detection and discharging to the liquid ammonia drain tank referred to in Sec 2, [5.3]. Arrangements are to be made to prevent vapour backflow through the drain pipe.

5 Power generation including propulsion and other fuel consumers

5.1 Ammonia engines

5.1.1 Ammonia engines are to comply with the relevant requirements of NR467, Pt C, Ch 1, App 2.

5.2 Design of engine components

5.2.1 *Unless designed with the strength to withstand the worst case overpressure due to ignited fuel leaks, engine components or systems containing or likely to contain an ignitable ammonia gas and air mixture are to be fitted with suitable pressure relief systems. Dependent on the particular engine design this may include the air inlet manifolds and scavenge spaces.*

5.2.2 *The explosion venting is to be led away from where persons may normally be present.*

5.2.3 The risk analysis required in Sec 1, [3] is to cover at least the hazard potential of ammonia releases or leakage:

- from crankcase and connected vent systems of trunk-piston engines
- from piston underside space (scavenge air space) of cross head engines
- from ammonia pipe enclosures
- towards engine auxiliary systems such as cooling water systems

5.2.4 For trunk-piston engines where gas concentration in the crankcase is above 110 ppm, the crankcase and connected vent piping are to be maintained at a pressure less than that in the engine room to prevent potential leakage, during engine operation and after engine is stopped.

5.2.5 Where their concentration exceeds 110 ppm, ammonia vapours from the engine crankcase are to be led to an ammonia release mitigation system.
Closed crankcase ventilation systems may be considered.

5.3 Exhaust systems

5.3.1 *The exhaust systems are to be configured to prevent any accumulation of unburnt fuel.*

5.3.2 *All fuel consumers are to have a separate exhaust system.*

Section 5 Fire Safety, Electrical Installations and Prevention of Exposure to Toxicity

1 Fire Safety

1.1 General

1.1.1 Provisions of NR529, Chapters 11 and 12, also apply to ammonia, except where otherwise specified in the present Section.

1.2 Inerting

1.2.1 An inert gas system complying with the provisions of NR529 Ch 3, Sec 1 [2.1.18], NR529 Ch 3, Sec 8, NR529 Ch 3, Sec 11 and NR529 Ch 3, Sec 12 is to be provided.

1.2.2 Inert gas containing carbon dioxide is not permitted.

1.3 Fire extinguishing

1.3.1 Water-based fire-fighting systems are not to be used on liquid ammonia fire.

2 Electrical installations

2.1 General

2.1.1 The provisions of NR529 Ch 7, Sec 4 for electrical installations also apply to ammonia, except where otherwise specified in the present Article.

2.2 Electrical equipment for hazardous areas

2.2.1 Electrical equipment for hazardous areas is to be of a certified safe type suitable for use in ammonia atmospheres. The types of electrical equipment admitted, depending on the zone where they are installed, are specified in NR467, Pt C, Ch 2, Sec 3, [10].

2.2.2 The electrical equipment in the liquid ammonia drain tank referred to in Sec 2, [5.3], is to be suitable for hazardous area zone 1.

3 Prevention of exposure to toxicity

3.1 Toxic exposure protection

3.1.1 Toxic areas and spaces are to be so arranged as to limit the risk of direct exposure to ammonia for persons on board.

3.1.2 Toxic areas and spaces are to be so arranged as to prevent cross-contamination from ammonia releases to lifesaving appliances, emergency escapes, air intakes, outlets and other openings into the accommodation, service and machinery spaces, control stations and other non-toxic spaces.

3.2 Toxic area and space classification

3.2.1 *Toxic areas include, but are not limited to:*

a) *areas on open deck within 10 m of any flanges, valves, and other potential leakage sources in ammonia fuel systems;*

b) *areas on open deck within B or 25 m, whichever is less, from outlets from the pressure relief valves installed on a liquefied fuel gas tank and all other fuel gas vent outlets*

c) *areas on open deck within B or 25 m, whichever is less, from outlets from interbarrier spaces for tanks of IMO type A;*

d) *areas on open deck within 10 m from outlets from interbarrier spaces for tanks of IMO type B;*

e) *areas on open deck within 10 m from outlets from secondary enclosures around ammonia piping, ventilation outlets from tank connection spaces and fuel preparation rooms and other spaces containing ammonia leakage sources;*

*Note 1: A*mmonia vapours from:

- the venting system of the secondary enclosures around ammonia piping
- the ventilation systems serving the bunkering station, tank connection and fuel preparation room

may be released directly to the open air only where permitted under Sec 2, [1.1.7].

f) areas on open deck within 10 m from the ammonia release mitigation system (ARMS) outlet;

g) areas on open deck within 10 m from the outlet of bilge water holding tanks vent pipes, when such tanks may contain dissolved ammonia;

h) areas on open deck within 5 m from inlets to secondary enclosures around ammonia piping, ventilation inlets to tank connection spaces and fuel preparation rooms and other spaces containing ammonia leakage sources; and

i) areas on open deck within 5 m from entrance openings to spaces containing ammonia leakage sources.

3.2.2 *Toxic spaces include, but are not limited to:*

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

b) tank connection spaces, interbarrier spaces and fuel storage hold spaces for tank containment systems requiring secondary barriers;

c) fuel preparation rooms;

d) annular space of secondary enclosures around fuel pipes;

e) enclosed and semi-enclosed spaces in which potential sources of release such as single-walled piping containing fuel are located;

f) enclosed and semi-enclosed bunker stations.

3.2.3 *In addition to the toxic area requirements in this section, a dispersion analysis is to be carried out in order to determine the extent of a toxic area. The gas dispersion analysis is to demonstrate that ammonia concentrations exceeding 220 ppm do not reach air intakes, outlets and other openings into:*

a) accommodation;

b) service and machinery spaces;

c) control stations;

d) other non-toxic spaces in the ship;

e) and other areas, as specified by the Society*;*

Note 1: The 220 ppm limit concentration applies to ammonia releases occurring during abnormal and emergency release scenarios.

3.2.4 Where the dispersion analysis required by [3.2.3] shows that, in case of leakage from an ammonia equipment located on open deck, ammonia concentrations exceeding the limit recommended by the risk analysis may occur at locations where persons may be present, an enclosure with liquid ammonia recovery and ammonia vapour mitigation through an ARMS may be required for the equipment.

3.2.5 The dispersion analysis is to demonstrate that, for abnormal and emergency release scenarios and considering the operational performance of the ARMS when intended to be used in such scenarios, the ammonia concentrations in way of the muster stations, life saving equipment and related access do not exceed the limit recommended by the risk analysis.

3.2.6 *The toxic area determined by the dispersion analysis is to extend the minimum area as defined in [3.2.1] or lead to additional mitigation measures.*

3.2.7 *The dispersion analysis boundary conditions are to be approved by the Society. The analysis is to include discharges from the pressure relief valves protecting the tank containment system, discharges from secondary barriers around fuel tanks and discharges from secondary enclosures around ammonia leakage sources.*

3.3 Safe havens

3.3.1 *A safe haven providing refuge in case of a release of ammonia is to be arranged in one or more enclosed spaces with a cumulative total capacity to accommodate all persons on board. Safe havens are to be arranged, as necessary, at essential locations for the ship's operation. The space is to be designed to minimize the risk of exposure to ammonia during release of ammonia. This may be achieved by measures including, but not limited to, arrangement of ventilation systems or by arranging self-sustaining air supply for the space.*

The number, location, design and arrangement of the safe havens are to be determined for the release scenarios referred to in [3.2.7] considering:

- the estimated time upon alarm activation, in case of leakage detection, to reach the safe haven from any location where persons may be present,
- the ammonia dispersion analysis
- the availability of readily accessible escape masks in the relevant locations

  and justified by a risk assessment.

3.4 Emergency equipment for personnel protection

3.4.1 *Suitably marked decontamination showers and eyewashes are to be available in convenient locations:*

- *close to bunkering stations;*
- *close to exit from tank connection spaces;*
- *close to exit from fuel preparation rooms;*
- *in machinery spaces for ammonia fuelled consumers; and*
- *close to lifeboat embarkation stations.*

The number and location of the showers and eyewashes are to be determined from the risk assessment and gas dispersion analysis, based on the worst leakage scenario.

3.4.2 *The showers and eyewashes are to be operable in all ambient conditions. A heating system with temperature control is required if pipe routing of the water supply exposes the piping to freezing conditions. Water supply capacity is to be sufficient for simultaneous use of at least two units. Thermal insulation is not considered as an alternative to a system with temperature control.*

3.5 Ammonia Release Mitigation System (ARMS)

3.5.1 *The fuel supply system is to include an ammonia release mitigation system capable of collecting and handling ammonia releases, including but not limited to:*

- *bleed from double block and bleed arrangements on the fuel piping systems;*
- *releases from the opening of pressure relief valves in the fuel piping system; and*
- *releases from purging and draining operations of fuel pipes.*

Note 1: This requirement applies only to gaseous ammonia releases.

3.5.2 The ammonia release mitigation system (ARMS) is to be capable of handling any operational ammonia releases. It may also be used to handle ammonia releases occurring in abnormal and emergency scenarios. See Sec 2, [1.1.4]

3.5.3 For single fuel installations, a fully redundant ammonia release mitigation system is to be provided. As an alternative, and subject to satisfactory FMECA, a single ARMS with redundant mechanical non-static components and components of the control system may be accepted.

3.5.4 *The release mitigation system is to be capable of reducing the ammonia concentration to below 110 ppm. Discharges from the release mitigation system are to be arranged in accordance with Sec 3, [2.2.7].*

3.5.5 The 110 ppm performance criterion applies to the operational ammonia releases.

3.5.6 Exhaust outlets from ammonia combustion units or boilers used as ARMS may be located less than the minimum distance from the exhaust outlets of machinery installations required by Sec 3, [2.2.7], item b), subject to satisfactory justifications.

3.5.7 Vent outlets from ammonia vapour dissolution tanks and discharge outlet from ammonia vapour dilution systems are to comply with the provisions of Sec 3, [2.2.6].

3.5.8 The summary of equipment or piping systems to be connected to the ARMS as per this Rule Note is given in Tab 1. Other equipment or piping systems may need to be connected to the ARMS depending on the result of the risk assessment.

Table 1 : Ammonia vapour streams from equipment or piping systems required to be treated by an ARMS

Equipment or system	Source of ammonia release	Reference	Nature of the ammonia release	Requirement for ammonia vapour handling
Reliquefaction system	Waste gases, if any	Sec 3, [4.3.1]	Operational release	Vapours are to be handled by an ARMS **(1)**
Bunkering lines	Vapours from purging operation, if not returned to fuel tank or bunkering facility	Sec 4, [3.4.1]	Operational release	Vapours are to be handled by an ARMS **(1)**
Line downstream of the double block and bleed valves (gaseous fuel)	Vapours released during automatic purging	Sec 4, [4.2.9]	Abnormal scenario release	Vapours may be released to the atmosphere when permitted **(2)**
Line between the shutoff valves of the double block and bleed arrangement (gaseous fuel)	Vapours released during venting of the line through the bleed valve	[3.5.1] Sec 4, [4.2.5]	Abnormal scenario release	Vapours are to be handled by an ARMS **(1)**
		[3.5.1] Sec 4, [4.2.8]	Operational release	
Gas-liquid separator	Vapours released through the vent line	Sec 4, [4.2.7]	Operational release	Vapours are to be handled by an ARMS **(1)**
Fuel pipes secondary enclosure	Vapours released from the inner pipe on engines in normal operation	Sec 2, [1.1.3]	Operational release	Vapours are to be handled by an ARMS **(1)**
	Vapours released in case of leakage from the inner pipe	Sec 4, [4.3.5] Sec 4, [4.2.7]	Abnormal scenario release	Vapours may be released to the atmosphere when permitted **(2)**
Fuel piping systems (gaseous)	Discharge from pressure relief valve	[3.5.1]	Abnormal scenario release	Vapours are to be handled by an ARMS **(1)**
	Vapours released during purging	[3.5.1]	Operational release	Vapours are to be handled by an ARMS **(1)**
	Vapours released during purging of the system when the temperature falls within 10°C of the calculated dew point	Sec 6, [1.2.2]	Operational release	Vapours are to be handled by an ARMS **(1)**
Storage tank	Vapours released during tank purging, inerting and venting	Sec 3, [1.5.2] and Sec 3, [1.5.3]	Abnormal scenario release	Vapours are to be handled by an ARMS **(3)**
Trunk-piston engines	Vapours released from crankcase venting system	Sec 4, [5.2.5]	Operational release	Vapours are to be handled by an ARMS **(1)**
Liquid ammonia drain tank	Vapours released from the tank vent pipe	Sec 2, [5.3.3]	Operational release	Vapours are to be handled by an ARMS **(1)**
Bilge water holding tank containing dissolved ammonia	Vapours released from the tank vent pipe	Sec 2, [4.4.2]	Operational release	Ammonia vapour concentration at the vent pipe outlet is to remain below 110 ppm **(4)**
Other equipment or systems containing a source of release	Vapour release handled through the space ventilation system	[4.3.1] Sec 2, [1.1.4]	Abnormal scenario release	Vapours may be released to the atmosphere when permitted **(2)**

(1) Except where their concentration remains below 110 ppm, operational releases and releases listed in [3.5.1] are to be handled through an ARMS complying with [3.5.4]. Refer to Sec 2, [1.1.3] and Sec 2, [1.1.7].

(2) Ammonia releases other than those referred to in **(1)** may be discharged directly to the atmosphere when the dispersion analysis required in [3.2.3] demonstrates that ammonia concentrations exceeding 220 ppm do not reach the spaces and areas listed in [3.2.3]. Otherwise, an ARMS may be used to reduce the concentrations below the required level. Refer to Sec 2, [1.1.4] and Sec 2, [1.1.7].

(3) Except where ammonia vapours are intended to be handled by the bunkering facility or by an onshore treatment facility, or where their concentration remains below 110 ppm. Refer to Sec 2, [1.1.7].

(4) An analysis is to be submitted to justify that the ammonia concentration at the vent outlet of the ammonia-containing bilge water holding tank is below 110 ppm. Where necessary, arrangements, such as neutralization, are to be made to reduce this concentration.

4 Ventilation

4.1 General

4.1.1 The following requirements apply in addition to those of NR 529, Ch 7, Sec 3.

4.2 Spaces containing a source of leakage

4.2.1 Tank connection spaces, fuel preparation room, enclosed or semi-enclosed bunkering stations and other spaces containing a source of leakage are to be fitted with effective mechanical ventilation systems capable of maintaining a pressure less than that in the adjacent spaces and with a capacity sufficient to maintain an ammonia vapour concentration below 40% LEL for the probable maximum leakage scenario. The ventilation capacity is not to be less than 30 air changes per hour.

Ammonia vapour concentrations are to be justified.

4.2.2 Any ducting used for the ventilation of a space containing a potential source of ammonia release is to be separate from that used for the ventilation of other spaces. Common ducting for spaces containing a potential source of ammonia release may be considered, subject to risk assessment.

4.3 Treatment of vapours released through the ventilation system

4.3.1 Where necessary to satisfy the 220 ppm ammonia concentration level referred to in [3.2.3], the ammonia vapours released through the ventilation system are to be led to an ARMS.

4.3.2 As an alternative to [4.3.1], a water mist system may be used to absorb ammonia vapours inside the space. It is to comply with the following provisions:

- The nozzles are to be so arranged as to avoid direct spraying on ammonia drip trays and possible sources of liquid ammonia leakage.
- The water mist system is to be activated manually in case of ammonia detection in the space. A procedure for safe activation of the water mist system is to be established and available on board.
- Upon release of the water mist, an audible and visual alarm is to be activated, and the ventilation fans are to stop automatically.
- Resulting water containing dissolved ammonia is to be drained to the dedicated bilge water holding tank required by Sec 2, [4.4].

Section 6 Control, Monitoring and Safety Systems

1 General

1.1 General requirements

1.1.1 *The control, monitoring and safety systems of the ammonia fuelled installation are to be so arranged that the remaining power for propulsion and power generation is in accordance with Sec 4, [4.1.1] in the event of single failure.*

1.1.2 *An ammonia safety system is to be arranged to close down the fuel supply system automatically, upon failure in systems as described in Tab 1 and upon other fault conditions which may develop too fast for manual intervention.*

1.1.3 *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.*

1.1.4 *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.*

1.1.5 *Where two or more fuel supply systems are required to meet the provisions, each system is to be fitted with its own set of independent fuel control and fuel safety systems.*

1.1.6 *Suitable instrumentation devices are to be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas equipment including bunkering.*

1.2 Prevention of condensation in fuel supply line

1.2.1 *Where gaseous ammonia fuel is supplied to a consumer, the following is to be monitored:*

- *fuel pipe wall temperature; and*
- *fuel pressure.*

1.2.2 *The control system is to be capable of calculating the dynamic dew point based on measurements of fuel pressure and fuel pipe wall temperature. If fuel pipe wall temperature falls within 10°C of the calculated dew point of the fuel, the fuel system is to shut down and fuel system is to be purged of ammonia fuel.*

Ammonia vapours from purging are to be led to the ARMS.

1.3 Ventilation

1.3.1 *Any reduction of the required ventilating capacity in bunkering stations, tank connection spaces, fuel preparation rooms or other enclosed spaces containing fuel piping or other fuel equipment not protected by a secondary enclosure is to give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre. Loss of ventilation is to result in automatic closing of valves as specified in Tab 1.*

1.4 Safety functions of fuel supply systems

1.4.1 *If the fuel supply is shut off due to activation of an automatic valve, the fuel supply is not to be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect is to be placed at the operating station for the shutoff valves in the fuel supply lines.*

1.4.2 *A caution placard or signboard is to be permanently fitted in the machinery space containing gas fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, is not to be done unless the fuel supply lines are free from ammonia.*

1.4.3 *Compressors, pumps and fuel supply are to be arranged for manual remote emergency stop from the following locations as applicable:*

a) navigation bridge;

b) cargo control room;

c) onboard safety centre;

d) engine control room;

e) fire control station; and

f) adjacent to the exit of fuel preparation rooms

1.4.4 *The ammonia compressor is also to be arranged for manual local emergency stop.*

Table 1 : Monitoring of ammonia fuel installation

Parameter	Alarm **(1)**	Automatic shutdown of : bunker valve	Automatic shutdown of : tank valve(s)	Automatic shutdown of : fuel preparation room valve(s)	Automatic shutdown of : master valve(s)	Comments
Ammonia detection in enclosed spaces at 25 ppm	X					• Local indication at all entrances to the space, no alarm at the alarm system • Visual and audible alarm inside the space
High-level fuel tank						
High-high level fuel tank	X	X	X			
Submerged fuel pumps, low level in tank	X					Stop fuel pumps at low-low liquid level
Ammonia detection in bunker station at 110 ppm	X					
Ammonia detection in bunker station at 220 ppm		X				
Liquid leakage detection in bunker station (drip trays)	X	X				• Close valve at low temperature • Automatic activation of the drip tray draining system in case of leakage detection
Ammonia detection in secondary enclosure around bunkering lines at 110 ppm	X					
Ammonia detection in secondary enclosure around bunkering lines at 220 ppm		X	X			
Liquid leakage detection in secondary enclosure around bunkering lines	X	X	X			Automatic activation of the enclosure draining system in case of leakage detection.
Ammonia detection in tank connection space at 110 ppm	X					
Ammonia detection on two detectors in tank connection space at 220 ppm	X		X			
Liquid leakage detection in tank connection space (drip trays)	X		X			• Close valve at low temperature • Automatic activation of the drip tray draining system in case of leakage detection
Ammonia detection in fuel preparation room at 110 ppm	X					
Ammonia detection on two detectors in fuel preparation room at 220 ppm	X			X		
(1) An alarm as indicated in this Table is to include an audible and visual alarm at a manned location in accordance with IMO 2009 Code on Alerts and Indicators.						

Parameter	Alarm **(1)**	Automatic shutdown of :				Comments
		bunker valve	tank valve(s)	fuel preparation room valve(s)	master valve(s)	
Liquid leakage detection in fuel preparation room (drip trays)	X			X		• Close valve at low temperature • Automatic activation of the drip tray draining system in case of leakage detection
Ammonia detection in secondary enclosure of fuel supply piping at 110 ppm	X					If the enclosure is maintained at a pressure less than that in the adjacent space by a redundant mechanical ventilation, alarm setpoint higher than 110 ppm may be accepted on a case-by-case basis
Ammonia detection on two detectors in secondary enclosure of fuel supply piping at 220 ppm	X		X	X	X	• All valves required to isolate the leakage are to close. • Transient releases which are expected in normal operation of the consumers are not to cause shutdown of the consumers. • If the enclosure is maintained at a pressure less than that in the adjacent space by a redundant mechanical ventilation, shutdown setpoint higher than 220 ppm may be accepted on a case-by-case basis
Liquid leakage detection in secondary enclosure of fuel supply pipes	X		X	X	X	• All valves required to isolate the leakage are to close • Automatic activation of the enclosure draining system in case of leakage detection
Reduced ventilation in tank connection space	X					
Loss of ventilation in tank connection space			X			
Reduced ventilation in fuel preparation room	X					
Loss of ventilation in fuel preparation room				X		
Reduced ventilation in bunkering station	X					
Loss of ventilation in bunkering station		X				
Manually activated emergency shutdown of master fuel valve(s) engine	X				X	
Ammonia concentration from discharge of ARMS at 110 ppm	X					
High level in liquid ammonia drain tank	X					

(1) An alarm as indicated in this Table is to include an audible and visual alarm at a manned location in accordance with IMO 2009 Code on Alerts and Indicators.

2 Bunkering and fuel tank monitoring

2.1 Level indicators for fuel tanks

2.1.1 *Each fuel tank is to be fitted with liquid level gauging device(s), arranged to ensure a level reading is always obtainable whenever the fuel tank is operational. The device(s) are to be designed to operate throughout the design pressure range of the liquefied gas fuel tank and at temperatures within the fuel operating temperature range.*

2.1.2 *Where only one liquid level gauge is fitted it is to be arranged so that it can be maintained in an operational condition without the need to empty or gas free the tank.*

2.1.3 *Fuel tank liquid level gauges may be of the following types:*

a) indirect devices, which determine the amount of fuel by means such as weighing or in-line flow metering; or

b) closed devices, which do not penetrate the fuel tank, such as devices using radioisotopes or ultrasonic devices.

2.2 Overflow control

2.2.1 *Each fuel tank is to be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.*

2.2.2 *An additional sensor operating independently of the high liquid level alarm is to automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the bunkering line and prevent the fuel tank from becoming liquid full.*

2.2.3 *The position of the sensors in the fuel tank is to be verified before commissioning. At the first occasion of full loading after delivery, testing of high-level alarms is to be conducted by raising the fuel liquid level in the fuel tank to the alarm point.*

2.2.4 *All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, are to be capable of being functionally tested. Systems are to be tested prior to fuel operation.*

2.2.5 *Where arrangements are provided for overriding the overflow control system, they are to be such that inadvertent operation is prevented. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre.*

2.3 Pressure and temperature indicators and alarms

2.3.1 *The vapour space of each fuel tank is to be provided with a direct pressure reading gauge. Additionally, an indirect pressure indication is to be provided on the navigation bridge, continuously manned central control station or onboard safety centre.*

2.3.2 *The pressure indicators are to be clearly marked with the highest and lowest pressure permitted in the fuel tank.*

2.3.3 *A high-pressure alarm and, if vacuum protection is required, a low pressure alarm are to be provided on the navigation bridge and at a continuously manned central control station or onboard safety centre. Alarms are to be activated before the set pressures of the safety valves are reached.*

2.3.4 *Each fuel pump discharge line and each liquid and vapour bunker manifold are to be provided with at least one local pressure indicator.*

2.3.5 *The local pressure indicators are to be provided to indicate the pressure between ship's bunker manifold valves and hose connections to the bunkering facility.*

2.3.6 *Fuel storage hold spaces and interbarrier spaces without open connection to the atmosphere are to be provided with pressure indicator.*

2.3.7 *For submerged fuel-pump motors and their supply cables, arrangements are to be made to alarm in low liquid level and automatically shut down the motors in the event of low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low low liquid level. This shutdown is to give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.*

2.3.8 *Each fuel tank is to be provided with devices to measure and indicate the temperature of the fuel.*

3 Bunkering control

3.1 General

3.1.1 *Control of the bunkering is to be possible from a safe location remote from the bunkering station. At this location the tank pressure, tank temperature, and tank level are to be monitored. Remotely controlled valves required by Sec 4, [3.4.3], are to be capable of being operated from this location. Overfill alarm and automatic shutdown are to be also indicated at this location.*

3.1.2 The bunkering control location is to be such that, in case of leakage from the bunkering system, it will not be exposed to ammonia concentrations exceeding the limit recommended by the risk analysis. This is to be justified by the dispersion analysis.

3.2 Leakage detection

3.2.1 *If ammonia leakage is detected in the secondary enclosure around the bunkering lines, an audible and visual alarm is to be provided at the bunkering control location. The bunker valve and other valves required to isolate the leakage are to be automatically closed by the safety system in accordance with Tab 1.*

3.2.2 If ammonia leakage is detected in the bunkering station drip trays, an audible and visual alarm is to be provided at the bunkering control location. The bunker valve and other valves required to isolate the leakage are to be automatically closed by the safety system in accordance with Tab 1.

4 Ammonia machinery monitoring

4.1 Ammonia compressor monitoring

4.1.1 *Gas compressors are to be fitted with audible and visual alarms both on the navigation bridge and in the engine control room. As a minimum the alarms are to include low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.*

4.1.2 *Where bulkhead penetrations are used to separate the drive from a hazardous space, temperature monitoring for the bulkhead shaft glands and bearings is to be provided, which automatically give a continuous audible and visual alarm on the navigation bridge or in a continuously manned central control station.*

4.2 Ammonia engine monitoring

4.2.1 Unless the risk analysis required by Sec 1, [3] proves otherwise, the monitoring and safety system functions for dual fuel or ammonia-only engines are to be provided in accordance with Tab 2 in addition to the general monitoring and safety system functions required by NR467.

Table 2 : Monitoring and Safety System Functions for Ammonia Fuelled Engines

Parameter	Alarm	Automatic activation of the double block-and-bleed valves	Automatic switching over to fuel oil mode **(1)**	Engine shutdown
Abnormal pressures in the ammonia supply line	X	X	X	X **(2)**
Ammonia supply systems - malfunction	X	X	X	X **(2)**
Malfunction of ammonia release mitigation system	X			
Leak detection in annular space of double walled pipes **(3)** **(4)**	X	X	X	X **(2)**
Pilot fuel injection or spark ignition systems - malfunction	X	X **(5)**	X	X **(2)** **(5)**
Exhaust gas temperature after each cylinder - high **(6)**	X	X **(5)**	X	X **(2)** **(5)**
Exhaust gas temperature after each cylinder, deviation from average - low **(6)** **(7)**	X	X **(5)**	X	X **(2)** **(5)**

(1) Applies only to dual fuel engines, when running in ammonia mode.
(2) Applies only to ammonia only engines.
(3) Leak detection of annular space may be off-engine and not within engine scope of supply.
(4) Refer also to Tab 1
(5) The double block-and-bleed valves and the engine shutdown may not be activated in case of specific failures affecting only one cylinder, provided that the concerned cylinder can be individually cut off from ammonia operation.
(6) Where monitoring of exhaust temperature or combustion for each cylinder is not practicable due to the engine size and design, common combustion monitoring may be accepted.
(7) Required only if necessary for the detection of misfiring.
(8) In the case where the failure can be corrected by an automatic mitigation action, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated.
(9) Where required by NR467, Pt C, Ch 1, Sec 2.
(10) Only for trunk piston engines. For crosshead engines slow down applies.
(11) Only for trunk piston engines.
(12) Applies to crankcase and vent piping extraction ventilation systems required by Sec 4, [5.2.4] and where required by the engine safety concept.
(13) Automatic safety actions to be activated as specified by the engine manufacturer.

Parameter	Alarm	Automatic activation of the double block-and-bleed valves	Automatic switching over to fuel oil mode **(1)**	Engine shutdown
Cylinder pressure or ignition - failure, including misfiring, knocking and unstable combustion **(6)**	X	X **(5)** **(8)**	X **(8)**	X **(2)** **(5)** **(8)**
Oil mist concentration in crankcase or bearing temperature - high **(9)**	X	X		X **(10)**
Pressure in the crankcase - high **(11)**	X	X	X	
Engine stops - any cause	X	X		
Failure of the control-actuating medium of the block and bleed valves	X	X	X	
Failure of crankcase ventilation system, if applicable **(12)**	X	X **(13)**	X **(13)**	

(1) Applies only to dual fuel engines, when running in ammonia mode.
(2) Applies only to ammonia only engines.
(3) Leak detection of annular space may be off-engine and not within engine scope of supply.
(4) Refer also to Tab 1
(5) The double block-and-bleed valves and the engine shutdown may not be activated in case of specific failures affecting only one cylinder, provided that the concerned cylinder can be individually cut off from ammonia operation.
(6) Where monitoring of exhaust temperature or combustion for each cylinder is not practicable due to the engine size and design, common combustion monitoring may be accepted.
(7) Required only if necessary for the detection of misfiring.
(8) In the case where the failure can be corrected by an automatic mitigation action, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated.
(9) Where required by NR467, Pt C, Ch 1, Sec 2.
(10) Only for trunk piston engines. For crosshead engines slow down applies.
(11) Only for trunk piston engines.
(12) Applies to crankcase and vent piping extraction ventilation systems required by Sec 4, [5.2.4] and where required by the engine safety concept.
(13) Automatic safety actions to be activated as specified by the engine manufacturer.

4.2.2 For trunk piston engines, crankcase pressure is to be monitored and in case of loss of underpressure, the double block and bleed valves are to be automatically activated.

4.2.3 Ammonia leakages in the secondary enclosure of the fuel supply piping are to be monitored in accordance with Tab 1. If the underpressure in the enclosure is maintained by a redundant mechanical ventilation, alarm setpoint higher than 110 ppm and shutdown setpoint higher than 220 ppm may be accepted on a case-by-case basis.

4.2.4 *In addition to the instrumentation provided in accordance with NR467, Part C and NR467, Pt F, Chapter 3, indicators are to be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:*

a) *operation of the engine in case of ammonia-only engines; or*

b) *operation and mode of operation of the engine in the case of dual fuel engines.*

5 Leakage detection

5.1 General

5.1.1 Where gas detection is to cause shutdown in accordance with Tab 1, detector voting is to be applied where two units are to detect gas to activate shutdown. A failed detector is to be considered as an active detection.

5.1.2 Gas detection required by this section is to be continuous without delay.

5.2 Gas detection

5.2.1 *Permanently installed gas detectors are to be fitted:*

a) *in tank connection spaces;*

b) *in all secondary enclosures around fuel pipes;*

c) *in machinery spaces containing gas piping, gas equipment or gas consumers;*

d) *in fuel preparation rooms;*

e) *in bunkering stations;*

f) *in other enclosed or semi-enclosed spaces where fuel vapours may accumulate including interbarrier spaces and fuel storage hold spaces of independent tanks other than type C;*

g) *in airlocks and entry spaces to tank connection spaces;*

h) *in gas heating circuit expansion tanks;*

i) *in motor rooms for compressors as specified in [4.1.2] (if fitted);*

j) *at ventilation inlets to accommodation and machinery spaces where required based on the risk assessment in Sec 1, [3]*

k) *at ventilation inlets for safe haven;*

l) *at outlet from tank pressure relief valves; and*

m) at outlet of the vent mast, where provided.

5.2.2 *The number of detectors in each space are to be considered taking into account the size, layout and ventilation of the space, and each space is to be covered by sufficient number of detectors to allow for voting in accordance with Tab 1.*

5.2.3 *The detection equipment is to be located where gas may accumulate and in the ventilation outlets. Gas dispersal analysis is to be used to find the best location of gas detectors.*

5.2.4 *Gas detection equipment is to be designed, installed, and tested in accordance with* IEC 60079-29-1:2020, or other standard deemed acceptable by the Society. In addition, gas detection sensors are to be submitted to the following type tests:

- Relevant tests required by NR467, Pt C, Ch 3, Sec 6, Tab 1
- Performance tests in accordance with IEC 62990-1:2022, clause 5.4.6, i.e.:
  - Alarm set-point(s)
  - Time to alarm or alarm reading
  - Flow rate (for aspirated equipment)
  - Warm-up time
  - Time of response
  - Time of recovery
  - Field calibration kit
  - Gas concentrations above the upper limit of indication
  - Extended operation in test gas
  - Orientation tests.

5.3 Liquid leakage detection

5.3.1 *Fuel piping is also to be arranged with detection of liquid leakages in the secondary enclosure at the lowest point.*

A detection of liquid leakage in the secondary enclosure is to activate the automatic draining of the enclosure in accordance with the provisions of Sec 4, [4.3.8].

5.3.2 *Each tank connection space, fuel preparation room and bunker station is to be provided with liquid leakage detection. Alarm is to be given at high liquid level and low temperature indication is to activate the safety system.*

5.3.3 Drip trays are to be arranged with detection of liquid leakage and automatic draining in accordance with the provisions of Sec 2, [5.2.6].

5.4 Alarm and safety system activation

5.4.1 *An audible and visible alarm is to be activated at an ammonia vapour concentration of 110 ppm. The safety system is to be activated at an ammonia vapour concentration of 220 ppm with actions. In addition, at an ammonia vapour concentration of 25 ppm, a visual local indication is to be given at all entrances to enclosed spaces affected, and an audible and visual alarm is to be given inside the space where the leakage is detected.*

5.4.2 *Audible and visible alarms from the leakage detection equipment are to be located on the navigation bridge, in the continuously manned central control station and inside and outside the space where the leakage is detected.*

Section 7 Manufacture, Workmanship and Testing

1 General

1.1

1.1.1 *The provisions of NR529 Chapter 9 apply to ships using ammonia as fuel, where appropriate.*

2 Certification of equipment

2.1 Ammonia detection system and ammonia scrubber unit

2.1.1 Equipment is to be certified according to NR529 Chapter 9, Sec 1, Tab 1, as corrected or completed by Tab 1.

Symbols used in the table have the following meaning:

TA : Indicates that Type Approval is required

DA : indicates that Design assessment / Appraisal of the product is required; this one may be carried out as applicable either for a specific unit or using the Type Approval procedure.

C : indicates that a BV product certificate is required with invitation of the Surveyor to attend the tests unless otherwise agreed, in addition to the manufacturer's document stating the results of the tests performed and/or compliance with the approved type as applicable.

W : indicates that a manufacturer's document is required, stating the results of the tests performed and/or stating compliance with the approved type (as applicable).

X : indicates that examinations and tests are required.

Table 1 : Certification of ammonia detection system and ammonia scrubber unit

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
1	Ammonia detection system	TA (1)		X	C	(1) See Sec 6, [5.2] and relevant provisions of NR467, Part F, Chapter 3 for automation systems
2	Ammonia scrubber unit (1)	TA or DA		X (2)	C	(1) See relevant provisions of NR467, Part C, Ch 1, Sec 11, applicable to exhaust gas cleaning systems (EGCS) (2) As per agreed program

Appendix 1 Correspondence with IMO MSC.1/Circ.1687 “Interim Guidelines for the Safety of Ships using Ammonia as Fuel”

1 Tables of correspondence

1.1 General

1.1.1 Correspondences between IMO MSC.1/Circ. 1687 and the present Rule Note are provided in Tab 1 and Tab 2.

Table 1 : Correspondence between IMO MSC.1/Circ.1687 sections 1 to 6 and current NR671

IMO Circ. 1687	Current NR678
1	–
2	–
2.1	–
2.2	–
2.2.1	Sec 1, [2.1.2]
2.2.2	Sec 1, [2.1.6]
2.2.3	Sec 1, [2.1.7]
2.2.4	Sec 1, [2.1.9]
2.2.5	Sec 1, [2.1.10]
2.2.6	Sec 1, [2.1.11]
2.2.7	Sec 1, [2.1.5]
2.3	–
3	–
3.1	–
3.2	–
3.2.1	–
3.2.2	–
3.2.3	–
3.2.4	–
3.2.5	–
3.2.6	–
3.2.7	–
3.2.8	–
3.2.9	–
3.2.10	–
3.2.11	Sec 2, [1.1.1]
3.2.12	–
3.2.13	–
3.2.14	–
3.2.15	–
3.2.16	–
3.2.17	–
3.2.18	–
3.2.19	–
3.2.20	–
4	–
4.1	–
4.2	–
4.2.1	Sec 1, [3.1.1]
4.2.2	Sec 1, [3.2.1]
4.2.3	Sec 1, [3.2.4]
4.3	Sec 1, [4.1.1]
5	–
5.1	–
5.2	–
5.2.1	–
5.2.2	Sec 2, [1.1.5]
5.2.3	Sec 2, [1.5.1]
5.2.4	–
5.2.5	–
5.2.6	–
5.2.7	–
5.3	–
5.3.1	Sec 2, [1.2.3]
5.3.2	Sec 2, [1.2.1]
5.3.3	Sec 2, [1.5.2]
5.3.4	Sec 2, [1.5.3]
5.4	Sec 2, [1.2.4]
5.5	–
5.5.1	Sec 2, [2.1.1]
5.5.2	Sec 2, [2.1.2]
5.5.3	Sec 2, [2.1.3]
5.5.4	Sec 2, [2.1.2]
5.5.5	Sec 2, [2.3.1]
5.5.6	Sec 2, [2.2.1]
5.6	Sec 2, [1.4]
5.6.1	Sec 2, [1.4.1]
5.6.2	Sec 2, [1.4.2]
5.6.3	Sec 2, [1.4.3]
5.7	–
5.7.1	–
5.7.1.1	Sec 2, [3.1.1]
5.7.1.2	Sec 2, [3.1.2]
5.7.1.3	Sec 2, [3.1.3]
5.7.1.4	Sec 2, [3.1.4]
5.7.1.5	Sec 2, [3.1.5]
5.7.1.6	Sec 2, [3.1.6]
5.7.1.7	Sec 2, [3.1.7]
5.7.1.8	Sec 2, [3.1.8]
5.7.1.9	Sec 2, [3.1.9]
5.7.1.10	Sec 2, [3.1.10]
5.7.2	–
5.7.2.1	Sec 2, [3.2.1]
5.7.2.2	Sec 2, [3.2.2]
5.7.2.3	Sec 2, [3.2.3]
5.7.2.4	Sec 2, [3.2.4]
5.7.2.5	Sec 2, [3.2.5]
5.7.2.6	Sec 2, [3.2.6]
5.7.2.7	Sec 2, [3.2.7]
5.7.2.8	Sec 2, [3.2.8]
5.7.2.9	Sec 2, [3.2.9]
5.7.3	Sec 2, [3.3]
5.7.3.1	Sec 2, [3.3.1]
5.7.3.2	Sec 2, [3.3.2]
5.7.3.3	Sec 2, [3.3.3]
5.8	Sec 2, [4]
5.8.1	Sec 2, [4.1.1]
5.8.2	Sec 2, [4.2.1]
5.8.3	Sec 2, [4.3.1]
5.9	Sec 2, [5.2]
5.9.1	Sec 2, [5.2.1]
5.9.2	Sec 2, [5.2.2]
5.9.3	Sec 2, [5.2.3]
5.9.4	Sec 2, [5.2.4]
5.9.5	Sec 2, [5.2.5]
5.9.6	Sec 2, [5.2.6]
5.10	Sec 2, [6.1]
5.10.1	Sec 2, [6.1.1]
5.10.2	Sec 2, [6.1.2]
5.10.3	Sec 2, [6.1.3]
5.10.4	Sec 2, [6.1.4]
5.11	Sec 2, [6.2]
5.11.1	Sec 2, [6.2.1]
5.11.2	Sec 2, [6.2.2]
5.11.3	Sec 2, [6.2.3]
5.11.4	Sec 2, [6.2.4]
5.11.5	Sec 2, [6.2.5]
5.11.6	Sec 2, [6.2.6]
6	–
6.1	–
6.2	–
6.3	–
6.3.1	Sec 3, [1.2.1]
6.3.2	Sec 2, [1.3.1]
6.3.3	Sec 3, [1.4.1]
6.3.4	Sec 3, [1.4.2]
6.3.5	Sec 3, [1.4.3]
6.3.6	Sec 3, [1.5.1]
6.3.7	Sec 3, [1.5.2]
6.4	–
6.4.1	Sec 3, [1.1.1]
6.4.2	Sec 3, [1.1.2]
6.5	–
6.6	–
6.7	–
6.7.1	Sec 3, [2.1]
6.7.1.1	Sec 3, [2.1.1]
6.7.1.2	Sec 3, [2.1.2]
6.7.2	Sec 3, [2.2]
6.7.2.1	Sec 3, [2.2.1]
6.7.2.2	Sec 3, [2.2.2]
6.7.2.3	Sec 3, [2.2.3]
6.7.2.4	Sec 3, [2.2.4]
6.7.2.5	Sec 3, [2.2.5]
6.7.2.6	Sec 3, [2.2.6]
6.7.2.7	Sec 3, [2.2.7]
6.7.2.8	Sec 3, [2.2.8] Sec 5, [3.2.7]
6.7.2.9	Sec 3, [2.2.9]
6.7.2.10	Sec 3, [2.2.10]
6.7.2.11	Sec 3, [2.2.11]
6.7.2.12	Sec 3, [2.2.12]
6.7.3	–
6.7.3.1	Sec 3, [2.3]
6.7.3.1.1	Sec 3, [2.3.1]
6.7.3.1.2	Sec 3, [2.3.2]
6.7.3.1.3	Sec 3, [2.3.3]
6.7.3.2	Sec 3, [2.4]
6.7.3.2.1	Sec 3, [2.4.1]
6.7.3.2.2	Sec 3, [2.4.2]
6.7.3.2.3	Sec 3, [2.4.3]
6.7.3.2.4	Sec 3, [2.4.4]
6.8	Sec 3, [3]
6.8.1	Sec 3, [3.1.1]
6.8.2	Sec 3, [3.1.2]
6.9	Sec 3, [4]
6.9.1	Sec 3, [4.1]
6.9.1.1	Sec 3, [4.1.1]
6.9.1.2	Sec 3, [4.1.2]
6.9.1.3	Sec 3, [4.1.3]
6.9.2	Sec 3, [4.2]
6.9.2.1	Sec 3, [4.2.1]
6.9.2.2	Sec 3, [4.2.2]
6.9.3	Sec 3, [4.3]
6.9.3.1	Sec 3, [4.3.1]
6.9.4	Sec 3, [4.4]
6.9.5	Sec 3, [4.5]
6.9.6	–
6.9.6.1	Sec 3, [4.6.1]
6.9.6.2	Sec 3, [4.6.3]
6.10	–

Table 2 : Correspondence between IMO MSC.1/Circ.1687 sections 7 to 20 and current NR671

IMO Circ. 1687	Current NR678
7	–
7.1	–
7.2	–
7.3	–
7.3.1	Sec 4, [2.1.1]
7.3.2	Sec 4, [2.2.1]
7.3.3	Sec 4, [1.1.1]
7.4	–
8	–
8.1	–
8.2	–
8.3	Sec 4, [3.1]
8.3.1	–
8.3.1.1	Sec 4, [3.1.1]
8.3.1.2	Sec 4, [3.1.2]
8.3.1.3	Sec 4, [3.1.3]
8.3.1.4	Sec 4, [3.1.4]
8.3.1.5	Sec 4, [3.1.5]
8.3.1.6	Sec 4, [3.1.6]
8.3.1.7	Sec 4, [3.1.7]
8.3.2	Sec 4, [3.2]
8.3.2.1	Sec 4, [3.2.1]
8.3.2.2	Sec 4, [3.2.2]
8.3.2.3	Sec 4, [3.2.3]
8.4	Sec 4, [3.3]
8.4.1	Sec 4, [3.3.1]
8.4.2	Sec 4, [3.3.2]
8.4.3	Sec 4, [3.3.3]
8.5	Sec 4, [3.4]
8.5.1	Sec 4, [3.4.1]
8.5.2	Sec 4, [3.4.2]
8.5.3	Sec 4, [3.4.3]
8.5.4	Sec 4, [3.4.4]
8.5.5	Sec 4, [3.4.5]
8.5.6	Sec 4, [3.4.6]
8.5.7	Sec 4, [3.4.7]
8.5.8	Sec 4, [3.4.8]
8.5.9	Sec 4, [3.4.9]
9	–
9.1	–
9.2	–
9.2.1	Sec 2, [1.1.2]
9.2.2	–
9.2.3	–
9.2.4	–
9.2.5	Sec 2, [1.1.3]
9.3	Sec 4, [4.1]
9.3.1	Sec 4, [4.1.1]
9.3.2	Sec 4, [4.1.2]
9.3.3	Sec 4, [4.1.3]
9.4	–
9.4.1	Sec 4, [4.2.1]
9.4.2	Sec 4, [4.2.2]
9.4.3	Sec 4, [4.2.3]
9.4.4	Sec 4, [4.2.4]
9.4.5	Sec 4, [4.2.5]
9.4.6	Sec 4, [4.2.6]
9.4.7	Sec 5, [3.5.1]
9.4.8	Sec 5, [3.5.4]
9.4.9	Sec 4, [4.2.7]
9.4.10	Sec 4, [4.2.8]
9.4.11	Sec 4, [4.2.9]
9.4.12	Sec 4, [4.2.10]
9.4.13	Sec 4, [4.2.11]
9.4.14	Sec 4, [4.2.12]
9.5	–
9.5.1	Sec 4, [4.3.1]
9.5.2	Sec 4, [4.3.2]
9.5.3	Sec 4, [4.3.7]
9.5.4	Sec 4, [4.3.3]
9.6	–
10	–
10.1	–
10.2	–
10.2.1	–
10.2.1.1	Sec 4, [5.3.1]
10.2.1.2	–
10.2.1.3	–
10.2.1.4	–
10.2.1.5	Sec 4, [5.2.3]
10.3	–
11	–
12	–
12bis	–
12bis.1	–
12bis.2	–
12bis.3	Sec 5, [3.1]
12bis.3.1	Sec 5, [3.1.1]
12bis.3.2	Sec 5, [3.1.2]
12bis.4	–
12bis.4.1	Sec 5, [3.2.1]
12bis.4.2	Sec 5, [3.2.2]
12bis.4.3	Sec 5, [3.2.3]
12bis.4.4	Sec 5, [3.2.6]
12bis.4.5	Sec 5, [3.2.7]
12bis.5	Sec 5, [3.3]
13	–
14	–
15	–
15.1	–
15.2	–
15.2.1	–
15.2.1.1	Sec 6, [1.1.1]
15.2.1.2	Sec 6, [1.1.2]
15.2.1.3	Sec 6, [1.1.3]
15.2.1.4	Sec 6, [1.1.4]
15.2.1.5	Sec 6, [1.1.5]
15.3	Sec 6, [1.1.6]
15.4	Sec 6, [2]
15.4.1	Sec 6, [2.1]
15.4.1.1	–
15.4.1.1.1	Sec 6, [2.1.1]
15.4.1.1.2	Sec 6, [2.1.2]
15.4.1.1.3	Sec 6, [2.1.3]
15.4.2	Sec 6, [2.2]
15.4.2.1	–
15.4.2.1.1	Sec 6, [2.2.1]
15.4.2.1.2	Sec 6, [2.2.2]
15.4.2.1.3	Sec 6, [2.2.3]
15.4.2.1.4	Sec 6, [2.2.4]
15.4.2.1.5	Sec 6, [2.2.5]
15.4.3	Sec 6, [2.3.1]
15.4.4	Sec 6, [2.3.2]
15.4.5	Sec 6, [2.3.3]
15.4.6	Sec 6, [2.3.4]
15.4.7	Sec 6, [2.3.5]
15.4.8	Sec 6, [2.3.6]
15.4.9	Sec 6, [2.3.7]
15.4.10	Sec 6, [2.3.8]
15.5	–
15.5.1	Sec 6, [3.1.1]
15.5.2	Sec 6, [3.2.1]
15.6	Sec 6, [4.1]
15.6.1	Sec 6, [4.1.1]
15.6.2	Sec 6, [4.1.2]
15.7	–
15.7.1	Sec 6, [4.2.4]
15.8	–
15.8.1	Sec 6, [5.1.1]
15.8.2	Sec 6, [5.2.1]
15.8.3	Sec 6, [5.2.2]
15.8.4	Sec 6, [5.2.3]
15.8.5	Sec 6, [5.2.4]
15.8.6	Sec 6, [5.3.1]
15.8.7	Sec 6, [5.3.2]
15.8.8	Sec 6, [5.4.1]
15.8.9	Sec 6, [5.4.2]
15.8.10	Sec 6, [5.1.2]
15.9	Sec 6, [1.2]
15.9.1	Sec 6, [1.2.1]
15.9.2	Sec 6, [1.2.2]
15.10	Sec 6, [1.3]
15.11	Sec 6, [1.4]
15.11.1	Sec 6, [1.4.1]
15.11.2	Sec 6, [1.4.2]
15.11.3	Sec 6, [1.4.3]
15.11.4	Sec 6, [1.4.4]
16	Sec 7
17	–
18	–
19	–
20	–
20.1	–
20.2	–
20.3	–
20.4	–
20.4.1	Sec 5, [3.4.1]
20.4.2	Sec 5, [3.4.2]
20.4.3	–
20.4.4	–
20.4.5	–
20.5	–

CHAPTER 3
AMMONIA FUEL PREPARED SHIPS

Section 1 Ammonia Fuel Prepared Ships

1 General

1.1 Application

1.1.1 The additional class notation **AMMONIAFUEL-PREPARED** is assigned to new ships that are designed to accommodate future installation of an ammonia fuel system, in accordance with the requirements of this Section. The following cases are considered:

a) The ship is designed for:
   - original operation on oil fuel and
   - future conversion to dual fuel operation, i.e. on oil fuel and ammonia fuel.

b) The ship is designed for:
   - original dual fuel operation on oil fuel and methane fuel and
   - future conversion to dual fuel operation with oil fuel and ammonia fuel, i.e. methane fuel is not used anymore.

c) The ship is designed for:
   - original dual fuel operation with oil fuel and methane fuel and
   - future conversion to tri-fuel operation, i.e. on oil fuel or methane fuel or ammonia fuel. Methane fuel and ammonia fuel can be used alternately or simultaneously.

d) The ship is designed for:
   - original dual fuel operation on oil fuel and LPG fuel and
   - future conversion to dual fuel operation with oil fuel and ammonia fuel, i.e. LPG fuel is not used anymore.

e) The ship is designed for:
   - original dual fuel operation with oil fuel and LPG fuel and
   - future conversion to tri-fuel operation, i.e. on oil fuel or LPG fuel or ammonia fuel. LPG fuel and ammonia fuel can be used alternately or simultaneously.

1.1.2 The additional class notation **AMMONIAFUEL-PREPARED** may be completed between brackets with one or a combination of the following notations **S**, **A**, **T**, **H**, **P** and **B**:

- **S** when specific arrangements are implemented for the ship structure at the original design stage with the aim of preventing the need for specific structural modifications at a later stage (see Article [3]).
- **A** when specific arrangements for ventilation and access to ammonia-related spaces are already on board (see Article [4]).
- When the ship is originally designed to use LNG or LPG as fuel:
  - **T** when at least one original LNG or LPG fuel storage tank can also be used with ammonia fuel, possibly with structural reinforcements in way of the tank and modifications of the operational conditions of the tank at a later stage (see Article [5])
  - **H** when the original LNG or LPG fuel handling equipment (pumps, heat exchangers, compressors) can also be used with ammonia (see Article [6])
  - **P** when the original LNG or LPG piping system can also be used with ammonia (see Article [7])
  - **B** when the original LNG or LPG boil-off gas management method (other than pressure accumulation, i.e. combustion unit, boiler or refrigerating system) can also be used with ammonia (see Article [8]).

Examples:

AMMONIAFUEL-PREPARED

AMMONIAFUEL-PREPARED (T)

AMMONIAFUEL-PREPARED (S,T,H)

1.1.3 When the ship is effectively converted to operate on ammonia fuel, the additional class notation **AMMONIAFUEL-PREPARED** is to be replaced by the additional class notation **ammoniafuel dualfuel**, provided that all the applicable requirements of Chapter 2, in particular those of Ch 2, Sec 1, are complied with.

1.2 Documentation to be submitted

1.2.1 The documentation listed in Tab 1 is to be submitted for ships to be assigned the additional class notation **AMMONIAFUEL-PREPARED**.

In addition, the documentation listed in Tab 2 to Tab 7 is to be submitted for notations **S**, **A**, **T**, **H**, **P** or **B**.

Table 1 : Documentation to be submitted for the additional class notation AMMONIAFUEL-PREPARED

No.	A/I **(1)**	Documentation	Particulars
1	I	Ammonia installation general arrangement	• General arrangement drawing of the ship showing the areas and spaces where ammonia may be present and the associated installations, either fitted at the new building stage or planned at a later stage, in particular: - the ammonia bunkering station(s) - the ammonia tank(s) - the ammonia boil-off management system(s) (refrigerating system, thermal oxidation system) - the ammonia fuel handling system - the ammonia valve units - the ammonia leakage treatment and recovery systems - the vent mast(s) - the inert gas system. • The equipment and systems installed at the new building stage and those intended to be installed at a later stage are to be clearly identified on the drawing.
2	I	General specification of the contemplated ammonia fuel installation	Including: • type and capacity of the ammonia storage tanks, range of pressure and temperature anticipated under operational conditions • bunkering method (from terminal, bunker ship or barge, truck) • boil-off management principle
3	A	Hazardous area plan	Drawing showing the hazardous areas and their classification, assuming that all ammonia installations are fitted onboard
4	A	Drawing showing the areas where ammonia may be present	
5	A	Drawing showing the structural fire protection and cofferdams provided in connection with ammonia installations	
6	A	Preliminary loading manual and loading conditions assuming the ammonia installation in ready-for-use condition	
7	A	Tank and Capacity Plan taking into account the ammonia installation in ready-for-use condition	
8	A	Intact stability calculations taking into account the ammonia installation in ready-for-use condition	
9	A	Damage Control Plan, Damage Stability Booklet, Damage Stability Calculations	• For ships having the additional class notation **SDS** • As applicable and taking into account the ammonia installation in ready-for-use condition
10	A	Arrangement of accesses to the spaces where ammonia may be present	
11	I	Calculation of the hull temperature in all design conditions	For membrane tanks, type A and type B tanks
12	A	Electrical load balance and heat balance anticipated with the use of ammonia as fuel	
13	I	Report of HAZID analysis	See [2.1.5]
(1) A: to be submitted for approval; I: to be submitted for information			

Table 2 : Additional documentation to be submitted for notation S

No.	A/I **(1)**	Documentation
1	A	Structural drawings for the following spaces: • ammonia bunkering station • ammonia tank holds • ammonia fuel handling room • ammonia valve unit room (where fitted)
2	A	Details of structural modifications and local reinforcements in way of machinery, piping components and supports of independent tanks associated with the use of ammonia as fuel
3	A	Holes and penetration drawings
(1) A: to be submitted for approval; I: to be submitted for information		

Table 3 : Additional documentation to be submitted for notation A

No.	A/I **(1)**	Documentation
1	A	Arrangement of the ventilation systems serving the spaces where ammonia may be present
2	A	Arrangement of accesses to the ammonia-related spaces
(1) A: to be submitted for approval; I: to be submitted for information		

Table 4 : Additional documentation to be submitted for notation T

No.	A/I **(1)**	Documentation	Particulars
1	I	Manufacturer's document describing the ammonia readiness of the original tank and the modifications foreseen at a later stage	
2	A	Tank material specification	
3	A	Structural drawings of ammonia tank(s) and supports	
4	A	Sloshing calculation covering the full range of intended filling levels	For membrane tanks, type A and type B tanks
5	A	Distribution of quality and steel grades in relation to the values obtained from the hull temperature calculation	For membrane tanks, type A and type B tanks
(1) A: to be submitted for approval; I: to be submitted for information			

Table 5 : Additional documentation to be submitted for notation H

No.	A/I **(1)**	Documentation	Particulars
1	I	Manufacturer's document describing the ammonia readiness of the original fuel handling system and the modifications foreseen at a later stage	
2	A	Justifications regarding the suitability of the concerned original LNG or LPG fuel handling equipment	• Pumps, heat exchangers, compressors) for use with ammonia • In particular with respect to operating characteristics, capacity and materials
(1) A: to be submitted for approval; I: to be submitted for information			

Table 6 : Additional documentation to be submitted for notation P

No.	A/I **(1)**	Documentation	Particulars
1	I	Manufacturer's document describing the ammonia readiness of the original fuel piping system and the modifications foreseen at a later stage	
2	A	Schematic diagram and arrangement of the ammonia (liquid and vapour) piping systems	Including venting systems
3	A	Arrangement of the venting mast	
(1) A: to be submitted for approval; I: to be submitted for information			

Table 7 : Additional documentation to be submitted for notation B

No.	A/I **(1)**	Documentation	Particulars
1	I	Manufacturer's document describing the ammonia readiness of the original boil-off vapour management system(s)	In particular its capability to control the tank pressure and temperature, and the modifications foreseen at a later stage
2	A	Calculations of the boil-off rate of the tank when containing ammonia	For the different operating conditions (maximum ambient temperature, filling rates, pressure and temperature in the tank after bunkering)
(1) A: to be submitted for approval; I: to be submitted for information			

1.3 Definitions

1.3.1 "Ammonia fuel handling system" means the equipment necessary for pumping, vaporizing, heating or compressing the ammonia fuel.

1.3.2 "Ammonia valve unit" means a set of shut-off valves, venting valves, pressure control valve, flow meter, filter and pressure/ temperature transmitters and gauges, located on the ammonia fuel supply to each consumer.

1.3.3 "Ammonia combustion unit" means a system intended for the combustion of boil-off ammonia vapour in excess or ammonia vapours from piping safety valve discharges, venting systems, etc.

1.3.4 "Ammonia dissolution system" means a system where ammonia vapours are dissolved in a water tank.

1.3.5 "Ammonia scrubber" means a system intended for dissolving ammonia vapours in sprayed water. It can be used as a mean to control the boil-off ammonia vapour in excess or to treat the ammonia vapour released from piping safety valve discharges, venting systems, etc.

1.3.6 "A space or area where ammonia may be present" means a space identified by the risk analysis as containing a possible source of leakage.

1.4 Ammonia main characteristics and consequences on the design of the ship installations

1.4.1 The main characteristics of ammonia that may influence the initial design of the ship with the aim to convert it to the use ammonia as fuel at a later stage are summarized in Tab 8.

Table 8 : Characteristics of ammonia that may influence the initial design of the ship

Characteristics	Typical value		Consequences on the design of ammonia installations versus methane fuel
	Ammonia	Methane fuel	
Liquid density (at 1 bar, in kg/m³)	672	422	• higher static and dynamic load on the tank structure • pumps may need to be replaced
Liquid volumetric energy density (LHV, in GJ/m³)	12,7	23,4	• larger volume for the storage tank • larger diameter for piping
Boiling point (at 1 bar, in °C)	–33	–161	lower heat ingress in the refrigerated storage tanks, less insulation or refrigerating capacity required
Vapour pressure (in bar)	18 (at 45°C) 10 (at 25°C)	–	• pressurized storage possible at ambient temperature • where ammonia is used in gaseous state, risk of condensation in case of temperature decrease
Latent heat of vaporization (kJ/kg)	1370 (at –33°C)	510 (at –161°C)	• ammonia requires higher heat amount for its vaporization • lower boil-off rate
Specific heat capacity C_p (liquid, kJ/kg.°C)	4,7	3,4	liquid ammonia requires higher heat for the same temperature increase
Toxicity			• ammonia is toxic when inhaled and for aquatic life when discharged into the sea • unburnt ammonia may be present in exhaust gases from engines
Global warming potential			N_2O in exhaust gases from engines is a strong greenhouse gas (GHG)
Corrosivity			use of materials compatible with ammonia

2 General requirements for the additional class notation AMMONIAFUEL-PREPARED

2.1 Design principles

2.1.1 The initial design of the ship is to take into account the specific characteristics of ammonia listed in [1.4].

2.1.2 The design of spaces intended to accommodate the ammonia storage tanks is to take into account the required fuel capacity to cover the operating range of the ship.

2.1.3 The additional electrical and thermal power that may be necessary to supply the ammonia systems is to be taken into account.

2.1.4 All parts of the ship that may be in contact with ammonia are to be made of materials compatible with ammonia.

2.1.5 An HAZID analysis is to be conducted to ensure that the risks arising from the use of ammonia fuel are addressed, in particular the risks related to its toxicity. Loss of function, system damage, spillage of liquid ammonia or release of ammonia vapours, fire and explosion are, as a minimum, to be considered. The results of the HAZID are to be implemented in the design of the ammonia systems.

2.2 General arrangement

2.2.1 The initial design of the ship is to take into account the necessary spaces or zones to accommodate the future installation of the following installations:

a) Ammonia fuel bunkering station
b) Ammonia fuel storage tanks
c) Ammonia fuel handling system
d) Ammonia boil-off management system, where required, including:
   - ammonia combustion unit
   - ammonia refrigerating system
   - ammonia dissolution system
   - ammonia scrubber.
e) Ammonia leakage drainage tank.
f) Ammonia effluents storage tank.
g) Ammonia vapour treatment systems.
h) Ventilation systems (independent systems).
i) Ammonia valve units.
j) Vent mast.

2.2.2 The arrangement and location of spaces where ammonia may be present are to comply with the provisions of Ch 2, Sec 2 .

2.2.3 The space below deck or the area above deck where the ammonia storage tanks will be installed are to comply with the requirements for protective location of the tank given in Ch 2, Sec 2, [1.2].

2.2.4 The access to spaces where ammonia may be present is to comply with the provisions of Chapter 2. Airlocks may be planned to be added at a later stage. When notation **A** is granted, see [4.1.1].

2.2.5 The hazardous and toxic area classification of the spaces where ammonia may be present is to be defined in accordance with the provisions of Ch 2, Sec 5.

2.3 Ship structure and stability

2.3.1 The ship stability is to be assessed for preliminary loading conditions, assuming the ammonia installation in ready-for-use condition, and to comply with the relevant provisions of the Rules. The relevant loads are to be stated.

The longitudinal strength of the ship is to be assessed, assuming the ammonia installation in ready-for-use condition, and to comply with the relevant provisions of the Rules.

2.4 Machinery

2.4.1 All installations and equipment necessary for the ship to operate on ammonia and that are fitted to the ship at the new construction stage are to comply with the relevant provisions of Chapter 2.

3 Additional requirements for notation S

3.1 General

3.1.1 The structural arrangements and reinforcements in way of machinery, piping components and supports of independent tanks associated with the use of ammonia as fuel are to be implemented at the new construction stage with the aim of preventing the need for specific structural modifications at a later stage.

4 Additional requirements for notation A

4.1 Access

4.1.1 The access to spaces where ammonia may be present is to comply with the provisions of Chapter 2.

Where required, airlocks are to be provided.

4.2 Ventilation

4.2.1 The ship ventilation is to be arranged in accordance with the provisions of Ch 2, Sec 5, [4], in particular as regards the separation between the ventilation systems serving spaces where ammonia may be present and those serving other spaces.

4.2.2 Ventilation systems are to be fitted with all necessary locations sized for fans compatible with the requirements of Ch 2, Sec 5, [4]. Such fans need not be installed at new construction stage.

5 Additional requirements for notation T

5.1 General

5.1.1 In addition to complying with the provisions of Article [2], ships having the notation **T** are to be provided with tanks also suitable for ammonia, as per [5.2].

The operational conditions of the tanks (e.g. operating pressure or maximum filling level) may however be modified at a later stage.

Note 1: Upon request, an Approval in Principle may be issued by the Society upon satisfactory completion of the procedure.

5.2 Design of the ammonia storage tank

5.2.1 Material compatibility

The original tank is to be made of a material complying with the provisions of Ch 2, Sec 4, [1].

5.2.2 Scantling

The scantling of the original tank is to take into account the higher static and dynamic load on the tank structure due to the density of liquid ammonia, the maximum expected service pressure and, where applicable, the sloshing loads for the full range of intended filling levels.

For membrane tanks, the reinforcements necessary for the containment systems are to be implemented at new construction stage.

5.2.3 Tank connections

The diameter of the tank connections is to be sufficient to allow the required flow rates, taking into account the energy density of ammonia and the permissible velocity.

The tank is to be fitted, at new construction stage, with all the connections necessary for operation with ammonia. In particular, where deemed necessary, a vapour return connection is to be fitted.

5.2.4 Pumps

Where original submerged pumps need to be replaced at a later stage, the corresponding parts of the tank (such as tank opening and pump supporting arrangements) are to be designed for the expected size of the ammonia pump.

5.2.5 Instrumentation

The tank is to be fitted, at new construction stage, with all the necessary penetrations for the instrumentation relevant to ammonia operation.

5.3 Ship structure

5.3.1 The ship structure in way of the tanks is to take into account the density of ammonia.

5.3.2 Where a type A tank, type B tank or a membrane tank is used for the storage of refrigerated ammonia fuel, the hull material in way of the tank is to be selected in relation to the values obtained from the hull temperature calculation.

6 Additional requirements for notation H

6.1 General

6.1.1 In addition to complying with the provisions of Article [2], ships having the notation **H** are to be provided with a fuel handling system also suitable for use with ammonia, as per [6.2].

Note 1: Upon request, an Approval in Principle may be issued by the Society upon satisfactory completion of the procedure.

6.2 Design of the ammonia fuel handling system

6.2.1 Design parameters

The fuel handling system intended for ammonia is to be designed for the pressure and temperature conditions and the flow rate required at the engine inlet.

The capacity of the ammonia fuel handling system is to take into account the characteristics of ammonia, in particular its volumetric energy density, heat of vaporization and heat capacity.

6.2.2 Material compatibility

The components of the ammonia fuel handling system are to be made of materials compatible with ammonia.

7 Additional requirements for notation P

7.1 General

7.1.1 In addition to complying with the provisions of Article [2], ships having the notation **P** are to be provided with a fuel piping system also suitable for use with ammonia, as per [7.2].

7.2 Design of the ammonia piping system

7.2.1 The piping system intended for ammonia is to be designed for the pressure and temperature conditions expected in the different parts of the system.

7.2.2 Pipe diameters are to be suitable for the maximum expected flow rates, taking into account the energy density of ammonia and the maximum allowable velocity.

7.2.3 Materials used for pipes (including the enclosing duct or pipe), valves and fittings are to be compatible with ammonia. This also applies to gaskets.

7.2.4 The risk of condensation in ammonia vapour lines, when the temperature in the concerned spaces may be below the saturation temperature of ammonia at the maximum service pressure, has to be taken into account. The design of the piping system is to allow heating arrangements to be added at a later stage, where necessary, to maintain ammonia at a sufficient temperature.

8 Additional requirements for notation B

8.1 General

8.1.1 In addition to complying with the provisions of Article [2], ships having the notation **B** are to be provided with a boil-off gas management system also suitable for use with ammonia, as per [8.2] and [8.3].

Note 1: Upon request, an Approval in Principle may be issued by the Society upon satisfactory completion of the procedure.

8.2 Design of the ammonia combustion unit (thermal oxidizer)

8.2.1 The combustion unit (thermal oxidizer) is to be originally designed so that it will ensure complete burning of ammonia for the full ranges of pressures, temperatures and flow rates of the ammonia boil-off vapours, while fulfilling the applicable emission standards.

8.2.2 Some components such as the burner, combustion fans, igniters, pilot burner or flame scanning system may be modified or replaced at a later stage.

8.2.3 Materials used for the different parts of the combustion unit or boiler, including piping, valves and fittings are to be compatible with ammonia.

8.3 Design of the refrigerating system

8.3.1 The refrigerating system is to be originally designed so that it will provide adequate refrigerating capacity for the ammonia liquid or vapours in the storage tanks to control its pressure.

8.3.2 Materials used for the different parts of the refrigerating unit, including piping, valves and fittings are to be compatible with ammonia.

BUREAU VERITAS MARINE & OFFSHORE

Tour Alto
4 place des Saisons
92400 Courbevoie - France
+33 (0)1 55 24 70 00

marine-offshore.bureauveritas.com/rules-guidelines

Shaping a World of Trust