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AMMONIA-FUELLED SHIPS TENTATIVE RULES

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RULE NOTE

BUREAU VERITAS

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RULES, RULE NOTES AND GUIDANCE NOTES

NR671 DT R02 September 2024 takes precedence over previous revision.

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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.

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NR671

AMMONIA-FUELLED SHIPS
TENTATIVE RULES

September 2024

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Section 1 General

1 Application

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 to minimize the risk to the ship, crew, passengers and the environment, taking into account the specific properties of ammonia, in particular its toxicity.

1.1.3 This Rule Note provides a set of design and installation requirements for the assignment of:

- the additional service feature **ammoniafuel**, for ships using ammonia as fuel in compliance with the requirements of Sec 2
- the additional class notation **AMMONIAFUEL-PREPARED**, for ships prepared to use ammonia as fuel in compliance with the requirements of Sec 3.

When the ship is effectively converted to operate on ammonia fuel, the additional class notation **AMMONIAFUEL-PREPARED** may be replaced by the additional service feature **ammoniafuel dualfuel**, provided that the requirements of Sec 3, [1.1.3] are fulfilled.

1.2 Statutory requirements

1.2.1 According to IGC Code regulation 16.9.2, liquefied gas carriers carrying ammonia are not allowed to use ammonia as fuel due to its toxicity. The Flag Administration of the ship is to be consulted to consider the possibility of using ammonia as fuel and the approval process to be followed.

1.2.2 For ships other than liquefied gas carriers intended to use ammonia as fuel, reference is made to the requirements of IGF Code, Part A, which requires an alternative design approach to be performed. The Flag Administration of the ship is to be consulted to define the approval process and the conditions in which the use of ammonia as fuel may be envisaged. In this respect, the Society considers that a ship design complying with the provisions of the present Rule Note and taking into account the outcome of the HAZID and HAZOP studies (see Sec 2, [2.3]) may be used as a basis for the engineering analysis required by SOLAS II-1 / reg. 55.3. The equivalence of the alternative design is to be demonstrated to and approved by the Flag Administration.

Note 1: When a ship is intended to use ammonia as fuel, the concerned Port Administrations need to be contacted to define the conditions in which the ship may operate in the area under their jurisdiction, in particular when the ship is at berth and during bunkering operations. Specific assessment, including dispersal analysis, may be required in this respect. This assessment is to cover the whole bunkering system, including the bunkering source and is to allow the definition of the toxic areas around the bunkering connections.

Section 2 Ammonia-fuelled Ships

1 Application

1.1 Scope

1.1.1 The purpose of this Section is to provide a set of design and installation requirements for the classification of ships using ammonia as a fuel.

1.1.2 This Section covers ammonia-fuelled installations where ammonia is stored in liquid state in:

- type A tanks at (or near) atmospheric pressure and refrigerated to a temperature of –33,3°C (fully refrigerated tank)
- type C tanks under pressure at ambient temperature (fully pressurised tank)
- type C tanks under pressure lower than the vapour pressure at ambient temperature (semi-pressurised tank).

Other storage arrangements may be considered on a case-by-case basis.

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

1.1.4 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 Classification

1.2.1 Ammonia-fuelled ships that are designed and built in accordance with this Rule Note may be assigned the additional service feature **ammoniafuel**.

The additional service feature **ammoniafuel** is completed by:

- the notation **singlefuel** when the engine uses only ammonia as fuel
- the notation **dualfuel** when the engine uses ammonia as fuel and fuel oil.

The additional service feature e.g. **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.

1.2.2 Ammonia-fuelled ships fitted with fuel cells using ammonia as fuel are to be assigned the additional service feature **fuelcell** as defined in NR467, Pt A, Ch 1, Sec 2, [4.13.2] and to comply with the requirements of NR547, Ships using fuel cells.

1.3 Documentation to be submitted

1.3.1 The documents listed in Tab 1 are to be submitted.

The list of documents requested is intended as a guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents if it is deemed necessary for the evaluation of the system, equipment or components.

Table 1 : List of documents to be submitted

No.	Documents to be submitted	I/A **(1)**
1	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 vapour processing systems • the vent mast • the inert gas system	A
(1) A: To be submitted for approval ; I: To be submitted for information		

No.	Documents to be submitted	I/A **(1)**
2	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	I
3	Drawing showing: • the hazardous areas and their classification • the toxic areas	A
4	Specification and plan showing the number and storage location of the PPE, emergency showers and eye rinsing equipment	A
5	General arrangement plan showing the spaces and areas containing a potential source of ammonia release	A
6	Drawing showing the structural fire protection and cofferdams provided in connection with ammonia installations	A
7	Details of fire-extinguishing appliances and systems related to ammonia installation: water-spray system when required, dry chemical powder, fire main	A
8	Arrangement of accesses to the spaces containing a potential source of ammonia release and to hazardous area zones	A
9	Airlocks between safe and hazardous area zones or spaces containing a potential source of ammonia release	A
10	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	A
11	Diagram of the bilge systems serving spaces containing a potential source of ammonia release	A
12	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.	A
13	Calculation of the hull temperature in all design conditions (for membrane tanks and type A tanks)	I
14	Distribution of quality and steel grades in relation to the values obtained from the hull temperature calculation (for membrane tanks and type A tanks)	A
15	Hull stress analysis	A
16	Schematic electrical wiring diagram in hazardous areas	A
17	Arrangement of electrical installation in hazardous areas, including lighting system	A
18	List of, and safety certificates for, electrical equipment located in hazardous areas	A
19	Details of electrical bonding of fuel tanks and piping	A
20	Ammonia detection system	A
21	Risk assessments as per [2.3] and [8.2.2] and follow-up report of the recommendations	I
22	Ammonia dispersion analysis, where required	A
23	Programme of gas trials	A
FOR THE AMMONIA FUEL CONTAINMENT SYSTEM:		
24	Scantlings, material and arrangement of the fuel containment system, including the secondary barrier, if any	A
25	Details of insulation	A
26	Details of ladders, fittings, swash bulkheads and towers in tanks and relative stress analysis, if any	A
27	Details of tank domes and deck sealings	A
28	Structural analysis for the tank(s) and supports as applicable	A
29	Hull ship motion analysis, where a direct analysis is preferred to the methods indicated in NR529, Chapter 6	A
30	Sloshing calculation covering the full range of intended filling levels (for membrane tanks and type A tanks)	A
31	Interbarrier space drainage, inerting and pressurisation systems if fitted	A
32	Ammonia containment system gas freeing procedure, including emptying, inerting and aerating	I
33	Ammonia tank instrumentation, including ammonia temperature monitoring system	A
34	Emergency shutdown system	A
35	Ammonia tank filling limits	A
36	Inspection/survey plan, as requested by NR529, [6.4.1.8]	A
FOR TANKS OTHER THAN FULLY TYPE C PRESSURISED TANKS:		
37	Specification of the boil-off vapour management system(s)	I

(1) A: To be submitted for approval ; I: To be submitted for information

No.	Documents to be submitted	I/A **(1)**
38	Calculations of the boil-off rate of the tank, for the different operating conditions (maximum ambient temperature, filling rates, pressure and temperature in the tank after bunkering)	A
FOR THE AMMONIA FUEL HANDLING SYSTEM:		
39	Specification, drawings, calculations and material characteristics of the pumps, compressors and heat exchangers	I
40	Details of process pressure vessels and relative valving arrangement	A
FOR THE AMMONIA FUEL PIPING SYSTEM:		
41	Schematic diagram and materials of the ammonia (liquid and vapour) piping systems, including venting systems	A
42	Plans, arrangement and calculations of safety relief valves	A
43	Details of the piping protective enclosure	A
44	Arrangement of the vent mast	A
FOR THE AMMONIA VAPOUR PROCESSING SYSTEMS:		
45	Specification of the ammonia vapour processing system	I
46	Justification of the ammonia vapour processing system capacity	A
FOR THE AMMONIA MACHINERY PLANT:		
47	Diagram of the fuel oil system including pilot fuel supply	A
48	Diagram of the engine lubricating oil system	A
49	Diagram of the engine cooling system	A
50	Diagram of the engine crankcase venting systems	A
51	Drawings of the boilers, including burners	A
52	Drawing of the exhaust gas ducts	A
53	Specification of the control, monitoring and safety systems for each ammonia utilization unit	A
54	Instrumentation list	A
55	Specification and type-approval reference of the ammonia utilization units	I
56	Diagram of the ammonia fuel supply systems, for each ammonia utilization unit	A
57	Arrangement of the GVUs	A
(1) A: To be submitted for approval ; I: To be submitted for information		

1.4 Definitions

1.4.1 Ammonia

Ammonia means NH_3, either in the liquid state or in the gaseous state.

1.4.2 Ammonia fuel system

Ammonia fuel system includes the ammonia bunkering, storage, preparation, supply and consuming systems.

1.4.3 Ammonia fuel preparation room

Ammonia fuel preparation room means any space containing pumps, compressors, heat exchangers and vaporizers for ammonia preparation purposes.

1.4.4 Ammonia vapour processing system

Ammonia vapour processing system means a system that destroys, recovers or disperses ammonia vapour by thermal oxidation, dissolution in water or dilution with air.

1.4.5 Ammonia vapour processing room

Ammonia vapour processing room means any space containing a system, or parts thereof, for processing ammonia vapours.

1.4.6 Design vapour pressure

Design vapour pressure is the maximum gauge pressure, at the top of the tank, to be used in the design of the tank.

1.4.7 Space containing a potential source of ammonia release

Space containing a potential source of ammonia release in the context of this Rule Note means a space where a single failure in a system or equipment or a consequential failure of it would result in a release of ammonia in the space. Such spaces are to be clearly identified by the risk analysis.

1.4.8 Normal operational condition

Normal operational condition has the same meaning as in SOLAS Convention, regulation II-1 / 3.5. It includes blackout situations.

1.4.9 Failure conditions

Failure conditions mean conditions under which a component in the ammonia fuel system is affected by a failure or a malfunction resulting in an ammonia leakage or an ammonia vapour release.

Note 1: "Failure conditions" include the loss of vacuum for vacuum-insulated type C tanks.

1.4.10 Permissible exposure limit (PEL)

Permissible exposure limit (PEL), for the purpose of this Rule Note, means a concentration of ammonia vapours in the air of 25 ppm, corresponding to the 8-hour TWA (time weighted average) limit given by US-OSHA.

1.4.11 Hazardous area

Hazardous area has the same meaning as in NR529, regulation 2.2.21.

1.4.12 Toxic area

Toxic area means an area in which a toxic atmosphere is or may be expected to be present, in quantities such as to require special precautions to avoid health effects on people.

For the purpose of this Rule Note, toxic areas are used only with respect to ammonia toxicity.

2 General design principles

2.1 Limitations of the toxicity consequences for persons on board

2.1.1 As a general principle, the release of ammonia is to be limited to the lowest practicable level.

2.1.2 Venting of ammonia to the atmosphere is permitted in normal conditions only if the ammonia concentration at the point of release (vent mast) does not exceed the PEL.

2.1.3 Venting of ammonia for control of the storage tank pressure as mentioned in [4.3.1] is not acceptable.

2.1.4 Venting of ammonia to the atmosphere is permitted in failure conditions provided that:

- the ammonia concentration at the point of release (vent mast) does not exceed 300 ppm, and
- it does not result in ammonia concentrations exceeding the PEL in any location where passengers or crew members may be present, or where ventilation inlets to accommodation spaces, machinery spaces and other accessible spaces are situated.

2.2 Limitations of the toxicity consequences for the environment

2.2.1 Except where otherwise stated, effluents containing liquid or dissolved ammonia are not to be discharged overboard.

2.3 Risk assessment

2.3.1 An exhaustive risk assessment is to be performed, considering the hazards associated with physical layout, operation, process and maintenance, following any reasonably foreseeable failure. The risk assessment is to include at least an HAZID study and an HAZOP study.

2.3.2 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 risks listed in paragraph 3.2 of IACS Rec.146, as deemed relevant to ammonia, are to be considered as well as the following ones:

- loss of function, including for the arrangements intended for mitigating the consequences of ammonia emissions
- component damage
- fire
- explosion
- collision
- grounding
- intoxication
- chemical burning
- pollution
- variations of bunkered ammonia fuel characteristics (temperature)
- rollover.

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

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

- the accumulation of ammonia vapours in spaces containing a potential source of ammonia release and their spreading over the ship's spaces through non-gastight openings
- the spreading of ammonia vapours from the vent mast outlet on open decks and their possible recirculation to accommodation through openings and ventilation inlets
- the formation of ammonia vapour cloud in the vicinity of the ship or in remote locations, taking into account the ambient conditions (e.g. humidity)
- the heat release in case of ammonia dissolution in water
- the draining of the hold space in case of type A tank failure.

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

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

The ammonia spreading scenarios in case of leakage, including ammonia spread through common ventilation ducting (see [11.2.1]), are to be analyzed.

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

2.3.6 Toxic areas around sources of release are to be assessed in accordance with standards EN IEC 60079-10-1:2021, substituting the lower flammable limit (LFL) with the PEL, and taking into account the scenarios identified during the risk assessment.

3 Ship design and arrangements

3.1 Protection of ammonia fuel storage tanks against external damages

3.1.1 Ammonia fuel storage tanks are to be protected against mechanical damage likely to occur during the ship operation.

3.1.2 Ammonia fuel storage tanks are to be protected from external damage caused by collision or grounding, in accordance with the requirements for protective location given in NR529, [5.3].

3.2 Location and protection of ammonia fuel piping

3.2.1 Ammonia fuel piping is not to be located less than 800 mm from the ship's side.

3.2.2 All ammonia fuel pipes are to be protected from mechanical damages likely to occur during the ship operation. This applies in particular to the ammonia fuel pipes located on open decks and to those led through ro-ro spaces and special category spaces.

3.2.3 Ammonia piping is not to be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations.

3.2.4 Any valve necessary for isolating a storage tank or other components of the ammonia fuel system in case of leakage is to be provided with a remote closing device, which is to be accessible from a protected location.

3.3 Leakage containments

3.3.1 Possible ammonia leakages, as identified by the HAZID, are to be contained by a suitable enclosure, wherever practicable.

3.3.2 All ammonia piping is to be enclosed in a protective gastight enclosure complying with [7.2].

3.3.3 The protective enclosures may be omitted:

a) in the following spaces:
   - ammonia tank hold spaces for tanks other than type C tanks
   - tank connection spaces
   - ammonia fuel preparation rooms
   - ammonia vapour processing rooms
   - bunkering stations

   provided that the provisions of [3.4.2] to [3.4.6] are complied with.

b) on open decks, for lines containing ammonia fuel only for short durations, such as bunkering lines, subject to justifications by risk analysis and dispersion studies.

c) for fully welded fuel gas vent pipes led through mechanically ventilated spaces.

Note 1: Lines between the ammonia storage tanks and the boil-off gas management systems are not considered as vent pipes.

3.4 Arrangement of spaces containing a potential source of ammonia release

3.4.1 Spaces containing a potential source of ammonia release are to comply with requirements [3.4.2] to [3.4.6].

3.4.2 Access

The access to the space should not be necessary in normal operational condition of the ship (except in the case of the bunkering stations, for which access is necessary for connecting and disconnecting the ammonia transfer hoses).

The access to the space is to be provided with locking arrangements which shall be under the control of the responsible ship's officer. A procedure is to be available on-board specifying the conditions to be observed for safe access to the space. A warning notice with safety instructions is to be provided outside the space, adjacent to each access door.

The space is to have a direct access to the open deck. Where this is not practicable, an alternative arrangement with an air lock may also be considered.

Direct access to the space is not permitted from another space. Where such access is necessary for operational reasons, an air lock is to be provided.

Note 1: Where permitted, airlocks are to allow the access of persons wearing breathing apparatus or carrying a stretcher.

3.4.3 Liquid ammonia leakage collection

Liquid leaks are to be collected in drip trays fitted with draining arrangement in accordance with [3.8].

3.4.4 Ammonia vapour detection

Ammonia sensors are to be provided in the space, giving an alarm when the ammonia vapour concentration reaches 25 ppm. The alarm is to be continuous, audible, and visual. The automatic shutdown of the master ammonia fuel valve or ammonia tank valve, as appropriate, is to be activated when the ammonia vapour concentration reaches 50 ppm. Refer also to [13.2.5].

Alarms are to be activated in the following locations:

- in the space
- outside the space, adjacent to each access door and
- in the control station.

3.4.5 Ventilation

The space is to be provided with an independent ventilation system arranged in accordance with the provisions of [11.2]. The maximum pressure build up in the space due to the ammonia evaporation and taking into account the ventilation system is to be assessed.

3.4.6 Bilge systems

The space is to be provided with a bilge system complying with the provisions of [3.7] and segregated from the bilge system serving other spaces.

The bilge lines serving the space are not to be connected to pumps located in other spaces.

3.5 Arrangement of machinery spaces

3.5.1 A single failure within the ammonia fuel system is not to lead to ammonia release into the machinery space.

3.5.2 All fuel piping within machinery space boundaries is to be enclosed in a gastight enclosure.

3.5.3 Ammonia sensors are to be provided in each machinery space giving an alarm before the ammonia vapour concentration reaches 25 ppm. The automatic shutdown of the master ammonia fuel valve is to be activated when the ammonia vapour concentration reaches 50 ppm. Refer also to [13.2.6].

3.6 Ammonia fuel preparation equipment

3.6.1 The equipment intended for ammonia fuel preparation is to be located in a dedicated space.

3.6.2 The pumping, vaporisation and heating capacity is to be sufficient to provide the required pressure and temperature of the ammonia supply at the ammonia consumer inlets in all ammonia conditions in the storage tank and, operating conditions of the consumers, including transient conditions, irrespective of the ambient conditions. Where necessary, a buffer tank is to be provided.

3.7 Regulations for bilge systems

3.7.1 Bilge water from spaces containing a potential source of ammonia release is to be retained on board in dedicated holding tanks for subsequent discharge to reception facilities. The oily bilge water holding tank may be used for such purpose if it complies with the provisions of [3.7.3] and [3.7.4].

3.7.2 In spaces where a water mist system is installed in pursuance of [10.3], the number and diameter of the scupper pipes or bilge suctions are to be sufficient to avoid any risk of water accumulation.

3.7.3 Bilge water holding tanks likely to contain dissolved ammonia are to be located outside the machinery spaces and provided with a vent pipe led to the vent mast and with means for ammonia vapour detection. They are to be made of a suitable material complying with the provisions of Article [5].

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

3.7.5 If the Flag Administration and the State or Port Administration in the jurisdiction of which the ship is intended to operate authorize the discharge of effluents containing dissolved ammonia directly overboard, an underwater discharge outlet may be provided in the vicinity of the turn of the bilge, so arranged as to avoid the re-intake of ammonia/water mixtures by the ship's seawater intakes.

Where discharge of aqueous ammonia overboard is permitted, to avoid the re-intake of ammonia/water mixtures by the ship's seawater intakes, the underwater discharge outlet may be arranged in accordance with the provisions of MARPOL Annex II, regulations 12.9 and 12.10. Alternatively, a CFD analysis may be considered to demonstrate that the ammonia dilution rate at the ship's seawater intakes is sufficient.

3.8 Draining systems for liquid ammonia

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

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

3.8.2 Drip trays are to be fitted with means for detecting a leakage and activating the safety systems.

3.8.3 Drip trays are to be connected to a liquid ammonia drain tank complying with [3.8.4]. The draining pipe is to be fitted with a remotely closable valve.

3.8.4 Liquid ammonia drain tanks are to be located outside the machinery spaces and provided with a vent pipe led to the ammonia vapour processing system and with means for ammonia vapour detection. They are to be made of a suitable material complying with the provisions of Article [5].

3.8.5 Liquid ammonia draining system and bilge water systems likely to contain dissolved ammonia are to be completely independent.

3.9 Control of ammonia vapours

3.9.1 Any release of ammonia vapours to the atmosphere, where permitted under [2.1], is to be made through a vent mast. Dispersion analysis may be required by the Society.

3.9.2 The vent mast outlet is to be located:

- At a height not less than B/3 or 6 m, whichever is the greater, above the weather deck, working areas and walkways. However, vent mast height may be limited to lower value subject to dispersion analysis demonstrating that the criteria in [2.1.4] is satisfied, i.e. the ammonia concentration in all locations where passengers or crew members may be present remains below the PEL in the worst-case release scenario.
- Not less than B or 25 m, whichever is less, from any opening or air intake to any accommodation and service spaces.

3.9.3 The vent mast may be used for other venting purposes provided there is no risk of flow reversal and chemical reaction between ammonia and other products.

3.9.4 The vent mast is to be designed for the direct discharge of the large amount of vapour from the tank safety valves in case of emergency situation (see Tab 2, Note (2)).

3.9.5 Ammonia vapours generated in normal operational condition of the ship may be led:

- to a suitable location within the ammonia fuel system, where feasible or
- to the ammonia vapour processing system, (see [10.2]), otherwise.

3.9.6 Ammonia vapours generated in failure conditions may be:

- led to a suitable location within the ammonia fuel system, where feasible or
- led to the ammonia vapour processing system (see [10.2]), or
- absorbed by water mist in accordance with [10.3] when the vapours are released directly into a space, or
- directly discharged to the atmosphere if permitted under [2.1.4].

3.9.7 Detailed requirements for the control of ammonia release are given in Tab 2.

Table 2 : Control of ammonia release

Ammonia release		Comments
Source	Method of vapour control	
Discharge from storage tank safety valves	Release to the vent mast	Only in case of emergency situation **(2)** See [4.3.3]
Discharge from safety valves in the ammonia fuel system other than the storage tank ones	Transfer to the storage tank or to other suitable location within the ammonia fuel system	
	Transfer to the ammonia vapour processing system	See [10.2]
Venting from bilge water holding tanks likely to contain dissolved ammonia	Release to the vent mast	See [3.7.3]
Venting from ammonia drain tanks	Transfer to the ammonia vapour processing system	See [10.2]
Discharge from pressure relief systems fitted to the type A tank hold spaces	Transfer to the ammonia vapour processing system	See [4.3.10], item g)
Venting from the diffusion water tank	Release to the vent mast	See [10.2.2]
Ventilation from the ammonia piping enclosure (in case of ammonia leakage detection)	Transfer to the ammonia vapour processing system	See [7.2.1], item a)] and [10.2]
	Release to the vent mast after dilution	See [10.2.5]
	Direct release to the vent mast	Only where permitted by [2.1.4] **(1)**
Venting from the ammonia supply system	Transfer to a suitable location within the ammonia fuel system	
	Transfer to the ammonia vapour processing system	See [10.2]
Leakage in a space containing a potential source of ammonia release	Dissolution by water mist in the space	See [11.2.4], item a)
	Transfer to the ammonia vapour processing system through the ventilation system	See [11.2.4], item b)
	Release to the vent mast through the ventilation system after dilution	See [11.2.4], item c)
	Direct release to the vent mast	Only where permitted by [2.1.4] **(1)**
Venting and purging with nitrogen of ammonia vessels and piping before inspection and maintenance	Transfer to the ammonia vapour processing system	See [14.1.1]

(1) Relevant justifications, including dispersion analysis, are to be submitted for the worst case release scenario, as identified by the risk analysis.

(2) Emergency situations where ammonia would be released at the vent mast are limited to the following ones:

- increased heat influx through the fuel containment system due to a fire in the vicinity of the tank, or flooding of the space containing the tank
- increased ammonia vapour generation in the tank due to a fire or flooding affecting the ammonia boil-off management system
- major loss of insulation system efficiency resulting in heat flux exceeding the limit stated in IGF 6.4.8.1, including loss of vacuum for vacuum insulated type C tanks.

4 Fuel containment system

4.1 General

4.1.1 Ammonia tanks are to be designed in accordance with the relevant provisions of NR529, Chapter 6, except where otherwise specified in the present Article.

4.2 Operating conditions of the storage tank

4.2.1 The operating conditions of the tank are to be detailed:

- expected pressure and temperature range of ammonia in the tank
- operating principle (vapour bleeding and liquid extraction) and relevant control principles.

4.3 Design and arrangement of ammonia tanks

4.3.1 With the exception of fully pressurised type C tanks, tanks' pressure and temperature are to be maintained at all times within their design range by means acceptable to the Society, e.g. by one of the following methods:

a) reliquefaction of vapours

b) thermal oxidation of vapours

c) pressure accumulation

d) liquefied ammonia fuel cooling

e) dissolution of vapours in water.

The method chosen is to be capable of maintaining tank pressure below the set pressure of the tank pressure relief valves for a period of 21 days assuming full tank at normal service pressure and the ship in idle condition, i.e. only power for domestic load is generated.

4.3.2 Except in the case of fully pressurised type C tanks, at least two independent methods, or independent systems if a single method is used, are to be provided, each one capable of maintaining a full boil-off gas management capacity in the situation where one of them becomes inoperative. One of the methods or systems is to be in stand-by mode and designed for immediate operation.

Note 1: Where pressure accumulation is one of the methods used for managing the boil-off gas, the system used as the second method and its supporting auxiliary services are to maintain the fuel tank pressure and temperature in case of a single failure of a mechanical non-static component or a component of the control systems. This is to be demonstrated by a FMEA analysis.

4.3.3 Opening of ammonia storage tank relief valves may occur only in case of overpressure resulting from an emergency situation (see Tab 2, Note (2)). The assessment of the ammonia dispersion scenario through the vent mast is to be carried out.

4.3.4 The Maximum Allowable Working Pressure (MAWP) of the ammonia tank is not to exceed 90% of the Maximum Allowable Relief Valve Setting (MARVS).

4.3.5 Loading and filling limits of the tank are to be in accordance with the provisions of NR529, [6.8.1] and [6.8.3].

4.3.6 Particular consideration is to be paid to a possible vacuum in the ammonia tank.

4.3.7 A water spray system is to be installed for cooling the exposed parts of tank(s) located on open deck.

4.3.8 Ammonia tanks, except fully pressurised type C tanks, are to be fitted with a vapor return line. Alternative arrangements allowing pressure management in the tank during bunkering may also be considered.

4.3.9 Additional requirements for fully pressurized type C tanks

The design pressure of fully pressurized type C tanks is not to be less than the vapour pressure of ammonia at the maximum ambient temperature expected in service with a minimum of 45°C. Higher values of ambient temperature may however be required, depending on the area in which the ship is intended to operate.

4.3.10 Additional requirements for type A tanks

Type A tanks are to comply with the following requirements:

a) The secondary barrier of the tank is to be a complete barrier capable of containing any envisaged leakage of ammonia fuel for a period of 15 days.

b) Where the secondary barrier is constituted by the ship's hull, it is to be constructed of suitable steel capable of withstanding a temperature of –33°C. See NR529, [6.4.13.1.1.2] and Table 7.5.

c) The sloshing loads on the containment system and internal components are to be evaluated for the full range of intended filling levels. CFD calculation or test campaign is to be carried out for verification of sloshing pressure without any limitation on the filling level.

d) Means for safely disposing of leakages from the tank are to be arranged.

e) The tank hold space is to be provided with a drainage system suitable for handling liquid ammonia in the event of tank leakage or rupture.

   Arrangements are to be made for:

   - draining limited amounts of liquid ammonia to a drain tank in case of tank leakage
   - discharging the large amounts of spilled liquid ammonia expected in case of tank rupture to the sea below the waterline. Relevant safety analysis and operating procedures are to be submitted to the Society.

f) The tank hold space is to be capable of being inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which is to be sufficient for normal consumption for at least 30 days (see NR529, [6.11.1]).

g) Tank hold spaces which may be subject to pressures beyond their design capabilities are to be provided with a suitable pressure relief system having a relieving capacity determined in accordance with NR467, Pt D, Ch 9, Sec 8, [2.1.4].

4.4 Tank pressure relief systems

4.4.1 The tank pressure relief system is to be in compliance with the provisions of NR529, [6.7.2] and [6.7.3].

5 Materials and general pipe design

5.1 General

5.1.1 The provisions of NR529, Chapter 7, for materials and piping systems also apply to ammonia, except where otherwise specified in the present Article.

5.1.2 Arrangements are to be made to deal with possible icing of ammonia piping components due to low temperatures in the ammonia storage tank or vaporization of pressurized ammonia fuel.

5.1.3 Piping systems containing liquid ammonia are to be designed for the vapour pressure of ammonia at the maximum expected temperature, considering a minimum of 45°C. Alternatively, safety valves are to be fitted where necessary to avoid any risk of overpressure in the piping system.

5.1.4 All pipelines or components which may be isolated in a liquid full condition are to be protected with relief valves for thermal expansion and evaporation.

5.2 Materials

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

5.2.2 Anhydrous ammonia may cause stress corrosion cracking in containment and piping systems made of carbon-manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in [5.2.3] to [5.2.9] are to be taken, as appropriate.

5.2.3 Where carbon-manganese steel is used, 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/mm^2, and with an actual yield strength not exceeding 440 N/mm^2. One of the following constructional or operational measures are also to be taken:

- lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 are to be used; or
- fuel tanks, etc., are to be post-weld stress relief heat treated; or
- ammonia temperature is to be maintained, preferably at a temperature close to the product's boiling point of –33°C, but in no case at a temperature above –20°C; or
- the ammonia is to contain not less than 0,1% w/w water. The relevant bunkering procedure is to be documented and made available onboard the ship.

5.2.4 If carbon-manganese steels with higher yield properties are used other than those specified in [5.2.2], the completed fuel tanks, piping, etc., are to be given a post-weld stress relief heat treatment.

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

5.2.6 Nickel steel containing more than 5% nickel and carbon-manganese steel, not complying with the requirements of [5.2.3] and [5.2.4], are particularly susceptible to ammonia stress corrosion cracking and are not to be used in containment and piping systems for ammonia.

5.2.7 Nickel steel containing not more than 5% nickel may be used, provided the temperature complies with the requirements specified in [5.2.3] third item.

5.2.8 Alternative metallic materials, as defined in IMO Circular MSC.1/Circ.1622/Rev.1, may be used if they are tested to the satisfaction of the ship flag Administration, in particular with respect to their resistance to stress corrosion cracking in ammonia environments.

5.2.9 To minimize the risk of ammonia stress corrosion cracking, arrangements are to be made to keep the dissolved oxygen content below 2,5 ppm w/w. Where appropriate, the relevant operational procedure is to be established and kept onboard the ship.

5.2.10 Gaskets and sealing are to be made of rubbers and polymers, such as PTFE, that are compatible with ammonia.

5.3 Prevention of phase changes in ammonia supply lines

5.3.1 Where ammonia fuel is intended to be used in the gaseous state at pressures close to the vapor pressure at expected ambient temperature, the fuel is to be sufficiently heated and the fuel lines are to be properly heat traced.

5.3.2 Where ammonia fuel is intended to be used in the liquid state, the pressure in the fuel manifold is to be sufficient to maintain the fuel in the liquid state.

6 Bunkering

6.1 General

6.1.1 The provisions of NR529, Chapter 8, for LNG bunkering also apply to ammonia, except where otherwise specified in the present Article.

6.2 Arrangement of the bunkering station

6.2.1 The bunkering station is to be of the enclosed or semi-enclosed type. It is to be arranged without dead spaces or obstacles that could lead to ammonia vapour accumulation.

6.2.2 The bunkering station is to be arranged with:

- an ammonia detection system
- an ammonia vapour processing system complying with [10.2] or a water mist system complying with [10.3]
- a ventilation system complying with Article [11]
- drip trays and a draining system for liquid ammonia complying with [3.8]
- a system for collecting effluents resulting from the use of the water mist system, where provided.

7 Fuel supply to consumers

7.1 General

7.1.1 The provisions of NR529, Chapter 9, for LNG fuel supply to consumers also apply to ammonia, except where otherwise specified in the present Article.

7.2 Secondary enclosure for ammonia fuel piping

7.2.1 Where required by [3.3], the secondary enclosure against leakage is to fulfill one of the following conditions:

a) Ventilated arrangement

The enclosure consists of a pipe or duct maintained at a pressure lower than the atmospheric pressure by an extraction ventilation system having a capacity of at least 30 air changes per hour.

An ammonia detector is to be provided at the fan discharge. In case of ammonia detection, the following automatic actions are to be performed:

- closing of the master ammonia fuel valve or ammonia tank valve, as appropriate
- activation of the vapour processing system, when required to satisfy [2.1.4] and not in permanent operation.

b) Inert gas-pressurized arrangement

The enclosure consists of a pipe or duct pressurized with inert gas at a pressure greater than the ammonia fuel pressure.

A pressure monitoring is to be provided for the space between the ammonia fuel pipe and the enclosure. Loss of inert gas pressure between the pipes is to be indicated by suitable alarms and is to activate the automatic closing of the master ammonia fuel valve or ammonia tank valve, as appropriate.

7.3 Master ammonia fuel valve

7.3.1 A master ammonia fuel valve is to be provided in accordance with the provisions of NR529, [9.4.2] and [9.4.3].

8 Power generation including propulsion and other ammonia consumers

8.1 General

8.1.1 The provisions of NR529, Chapter 10, for LNG consumers also apply to ammonia, except where otherwise specified in the present Article.

8.2 Internal combustion engines using ammonia as fuel

8.2.1 Ammonia engines are to be type approved on the basis of the risk assessment (see [8.2.2]) and type testing (see [8.2.4]).

8.2.2 The risk assessment of the engine is to be carried out using an FMEA analysis or other acceptable methods. It should cover in particular the following hazards:

- presence and possible accumulation of gaseous ammonia in the charge air system and in the crankcase (Otto cycle engines)
- condensation of ammonia vapours in the fuel supply system (Otto cycle engines)
- leakage of high pressure liquid ammonia (Diesel cycle engines)

- presence of unburnt ammonia vapours in the exhaust system
- failure of an ammonia admission valve or injection valve
- failure of the ignition system (sparking plug or pilot injection).

8.2.3 Where their concentration exceeds the PEL, ammonia vapours from the engine crankcase are to be led to the ammonia vapour processing system referred to in [10.2]. Dilution of ammonia vapours with fresh air or exhaust gases may be also accepted if the ammonia concentration at the point of release does not exceed the PEL.

8.2.4 The engine is to undergo at least the following type tests, in addition to those required in NR467, Pt C, Ch 1, Sec 2, for standard Diesel engines:

- For dual fuel engines, the lowest specified speed is to be verified in diesel mode and ammonia mode.
- For dual-fuel engines, switch over between ammonia and diesel modes are to be tested at different loads.
- The efficiency of the ventilation arrangement of the double walled ammonia piping system is to be verified.
- The capability of engines driving generators to take sudden load and loss of load is to be verified.

Note 1: Where necessary, an exhaust gas treatment system is to be provided in order to comply with the applicable NOx emission limits stated in MARPOL Annex VI.

8.3 Fuel cells

8.3.1 Fuel cell systems using ammonia are to comply with the relevant requirements given in NR547.

9 Fire safety and explosion prevention

9.1 General

9.1.1 The provisions of NR529, Chapters 11 and 12, also apply to ammonia, except where otherwise specified in the present Article.

9.2 Inerting

9.2.1 An inert gas system complying with the provisions of NR529, [6.3.12], [6.10], [6.13] and [6.14] is to be provided.

9.2.2 Inert gas containing carbon dioxide is not permitted due to contamination of ammonia by carbamates formed as a result of a chemical reaction.

9.3 Fire extinguishing

9.3.1 Water based firefighting systems are not to be used on liquid ammonia fire due to instantaneous vaporization of the liquid phase.

9.4 Static electricity

9.4.1 All piping and pieces of equipment are to be electrically bonded.

10 Arrangements for mitigating the consequences of ammonia emissions

10.1 General

10.1.1 Where required in [3.9] or [8.2.3], ammonia concentration in the vapours released from the ammonia fuel system is to be reduced by means of a dedicated ammonia vapour processing system complying with the provisions of [10.2] and having a capacity and performance suitable to ensure that the ammonia concentration levels required in [2.1.2] and [2.1.4] are complied with.

10.1.2 Where necessary to comply with the ammonia concentration levels required in [2.1.4], the ammonia vapours released in case of ammonia leakage in a space containing a potential source of ammonia release are to be controlled by means of:

- one of the ammonia vapour processing systems referred to [10.2] or
- a water mist released within the space in accordance with the provisions of [10.3].

10.1.3 The thermal oxidation systems and dissolution systems (scrubbers) used as methods for controlling the pressure and temperature in the ammonia storage tank (see [4.3.1]) may also be used to reduce the ammonia concentration in ammonia releases.

10.2 Ammonia vapour processing systems

10.2.1 The ammonia vapour processing systems that may be used are listed in Tab 3. They may be used in normal operational or failure conditions, as indicated in Tab 3. Other processing systems will be given special consideration.

Ammonia scrubber and ammonia combusting unit are to be located in a dedicated space.

The outlet of the ammonia scrubber and ammonia combustion unit is to be located in accordance with the provisions of [3.9.2].

Table 3 : Use of ammonia vapour processing systems

Ammonia vapour processing system	Use in normal / failure conditions
Ammonia diffusion tank	normal operational and failure conditions
Ammonia scrubber	
Ammonia combustion unit	
Dilution system	failure condition

10.2.2 Ammonia diffusion tank

The ammonia diffusion tank is to be designed to receive the discharge from the pressure-relief devices or vent pipes. The discharge pipe is to distribute ammonia in the bottom of the diffusion tank, but not lower than 10 m below the maximum liquid level.

The capacity of the system is to be based on the solubility of ammonia at the concerned temperature. The tank is to contain the volume of water and ammonia without overflowing. The water is to be prevented from freezing.

Note 1: The volume of water in the tank is to be not lower than 8 liters of water for each kilogram of ammonia to be dissolved.

The tank is to be provided with a vent pipe connected to the vent mast. An ammonia sensor is to be installed on the vent pipe.

The tank is to be provided with:

- a level indicator and low- and high-level alarms, and
- sensors for pH and electrical conductivity.

The materials of the tank and related piping (diffusion pipe, discharge pipe and vent pipe) are to comply with the provisions of Article [5].

The tank is to be provided with means of discharge to a land-based reception facility.

10.2.3 Ammonia scrubbers

The ammonia scrubber may be maintained in permanent operation or ready for starting in case of ammonia release detection.

The ammonia scrubber is to be of the closed-loop type. Where a neutralizing acid is used, the storage tank and piping distribution system are to comply with the relevant provisions of NR467, Pt C, Ch 1, Sec 10, [18.5.4].

The materials used for the scrubber components (spray chambers, water jet piping, etc.) are to comply with the provisions of Article [5].

10.2.4 Ammonia combustion unit

Unless otherwise stated below, the ammonia combustion unit is to comply with the requirements of NR467, Pt C, Ch 1, Sec 3, [7].

The ammonia combustion unit is to be designed to operate throughout the expected flow range while limiting the unburnt amount of ammonia.

A pilot flame is to be provided to initiate and sustain the combustion of ammonia.

The ammonia combustion unit is to be capable of immediate operation upon opening of a safety valve or venting valve. A buffer tank is to be provided where necessary for this purpose.

A phase separator (knockout drum) is to be installed to prevent liquid ammonia (droplets) to enter the ammonia combustion unit without being totally evaporated.

10.2.5 Dilution system

The dilution system is to be arranged to provide sufficient dilution of the ammonia-containing gaseous effluents by mixing them with fresh air or increasing the ventilation rate.

The dilution rate is to be sufficient to reduce the ammonia concentration in accordance with [10.1.1]. Relevant justifications based on the maximum ammonia emission rate are to be submitted for each venting and ventilation scenario.

The risks in connection with the flammability of the ammonia / air mixture are to be evaluated.

10.3 Water mist system for ammonia vapours absorption in a space

10.3.1 Where provided, the water mist system is to be arranged to absorb ammonia vapours in the space so as to reduce the ammonia concentration in accordance with [10.1.2].

10.3.2 The nozzles are to be so arranged as to avoid direct spraying on ammonia drip trays and possible sources of liquid ammonia leakage.

10.3.3 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.

10.3.4 An audible and visual alarm is to be activated in case of activation of the water mist.

11 Ventilation

11.1 General

11.1.1 The provisions of NR529, Chapter 13, for ventilation also apply to ammonia, except where otherwise specified in the present Article.

11.2 Arrangement of the ventilation systems serving spaces containing a potential source of ammonia release

11.2.1 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.

11.2.2 The ventilation capacity is to be at least 30 air changes per hour.

11.2.3 Ventilation outlets are to be provided both in the lowest and highest parts of the space and suitably protected.

11.2.4 In spaces protected by an ammonia vapour processing system, the ventilation system is to be so arranged that, in case of ammonia leakage detection in the space, the following actions are performed:

a) the ventilation outlet is automatically directed to the ammonia vapour processing system, or

b) the ammonia concentration at the ventilation outlet is reduced by automatic activation of a dilution system using fresh air or automatic increase of the ventilation rate, so that resulting ammonia concentrations comply with the provisions of [2.1.4]. Relevant justifications are to be submitted.

11.2.5 In spaces protected by water-mist, the ventilation fans are to stop automatically upon release of the water-mist in accordance with [10.3.3].

12 Electrical installations

12.1 General

12.1.1 The provisions of NR529, Chapter 14, for electrical installations also apply to ammonia, except where otherwise specified in the present Article.

12.2 Electrical equipment for hazardous spaces

12.2.1 Electrical equipment for hazardous areas is to be certified for ammonia in accordance with IEC 60079-20-1.

13 Control, monitoring and safety systems

13.1 General

13.1.1 The provisions of NR529, Chapter 15, for control, monitoring and safety systems also apply to ammonia, except where otherwise specified in the present Article.

13.2 Regulations for ammonia vapour detection

13.2.1 Permanently installed ammonia detectors providing a 25 ppm ammonia concentration alarm are to be fitted:

- in the tank connection spaces
- in all ducts around fuel pipes
- in ammonia fuel preparation rooms
- in ammonia vapour processing rooms
- in other spaces containing a potential source of ammonia release
- in machinery spaces containing ammonia piping, equipment or consumers
- in air locks
- in ammonia heating circuit expansion tanks
- in engine cooling water expansion tanks
- in motor rooms associated with the ammonia systems
- in bunkering stations
- in vent pipes from ammonia drain tanks
- in vent pipes from bilge water holding tanks serving spaces containing a potential source of ammonia release

- at ventilation inlets to accommodation, service spaces, control stations and machinery spaces and other accessible spaces if required based on the risk assessment and dispersion analysis
- at the vent mast outlet
- at the ammonia scrubber or ammonia combustion unit outlet (as applicable).

13.2.2 When they are not connected to the ammonia vapour processing system (see [8.2.3]), vent lines from engine crankcases are to be fitted with an ammonia detector at the point of release to the atmosphere.

13.2.3 The detection equipment fitted in spaces is to be located where ammonia vapours may accumulate and taking into account the ambient conditions, the service pressure and temperature of the ammonia system, the ammonia vapour density and the ventilation air velocities.

13.2.4 At least two detectors are to be provided at each location. The total number of detectors in each space is to be considered taking into account the size and layout or the space.

13.2.5 Ammonia dispersion analysis or smoke tests are to be carried out to justify the detector arrangement (number and location) in the following spaces:

- fuel preparation rooms
- tank connection spaces
- bunkering stations.

13.2.6 Ammonia vapour detectors are to be of self-monitoring type, whereby any failure of the sensor, electronics or transducer, triggers an alarm.

13.2.7 Alarm and safety systems are to be activated as follows:

- Alarm systems are to be activated when:
  - one detector detects a 25 ppm ammonia concentration or
  - a failure is detected by the self-monitoring function of a detector.
- Safety systems are to be activated when:
  - two sensors detect a 50 ppm ammonia concentration or
  - a failure is detected by the self-monitoring function of a detector and the other detector detects a 50 ppm ammonia concentration.

13.3 Personal protection

13.3.1 The following equipment is to be available on board:

- protective clothing fully resistant to ammonia
- breathing apparatuses with spare charges
- emergency showers and eye rinsing equipment.

The number and location of these pieces of equipment are to be clearly shown on the fire control plan.

14 Inspection and maintenance

14.1 Piping arrangement

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

Section 3 Ammoniafuel Prepared Ships

1 General

1.1 Application

1.1.1 The additional class notation **AMMONIAFUEL-PREPARED** is granted 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 the conversion 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 the ship conversion 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** may be replaced by the additional service feature **ammoniafuel dualfuel**, provided that all the applicable requirements, in particular those of Sec 2, are complied with.

1.2 Documents and information to be submitted

1.2.1 The plans and documents to be submitted are listed in Tab 1.

Table 1 : Documents to be submitted

Notation	No.	Documents and information to be submitted	(A/I) **(1)**
AMMONIAFUEL-PREPARED		For all ships (see [2]):	
	1	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), where fitted • 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.	A
	2	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	I
	3	Drawing showing the hazardous areas and their classification, assuming that all ammonia installations are fitted onboard	A
	4	Drawing showing the areas where ammonia may be present	A
	5	Drawing showing the structural fire protection and cofferdams provided in connection with ammonia installations	A
	6	Preliminary loading manual and loading conditions assuming the ammonia installation in ready-for-use condition	A
	7	Tank and Capacity Plan taking into account the ammonia installation in ready-for-use condition	A
	8	Intact stability calculations taking into account the ammonia installation in ready-for-use condition	A
	9	For ships having the additional class notation **SDS**: • Damage Control Plan • Damage Stability Booklet • Damage Stability Calculations as applicable and taking into account the ammonia installation in ready-for-use condition	A
	10	Arrangement of accesses to the spaces where ammonia may be present	A
	11	Calculation of the hull temperature in all design conditions (for membrane tanks and type A tanks)	I
	12	Electrical balance and heat balance anticipated with the use of ammonia as fuel	A
	13	Report of HAZID analysis (see [2.1.5])	I
S		For the hull structure (see [3]):	
	14	Structural drawings for the following spaces: • ammonia bunkering station • ammonia tank holds • ammonia fuel handling room • ammonia valve unit room (where fitted)	A
	15	Details of structural modifications and local reinforcements in way of machinery, piping components and supports of Type-A or Type-C tanks associated with the use of ammonia as fuel	A
	16	Holes and penetration drawings	A

(1) A: document to be submitted for approval; I: document to be submitted for information

Notation	No.	Documents and information to be submitted	(A/I) **(1)**
A	17	Arrangement of the ventilation systems serving the spaces where ammonia may be present	A
	18	Arrangement of accesses to the ammonia-related spaces	A
T		For the fuel tank (see [5]):	
	19	Manufacturer's document describing the ammonia readiness of the original tank and the modifications foreseen at a later stage	I
	20	Tank material specification	A
	21	Structural drawings of ammonia tank(s) and supports	A
	22	Sloshing calculation covering the full range of intended filling levels (for membrane tanks and type A tanks)	A
	23	Distribution of quality and steel grades in relation to the values obtained from the hull temperature calculation (for membrane tanks and type A tanks)	A
H		For the fuel handling system (see [6]):	
	24	Manufacturer's document describing the ammonia readiness of the original fuel handling system and the modifications foreseen at a later stage	I
	25	Justifications regarding the suitability of the concerned equipment (pumps, heat exchangers, compressors) for use with ammonia, in particular with respect to operating characteristics, capacity and materials	A
P		For the fuel piping system (see [7]):	
	26	Manufacturer's document describing the ammonia readiness of the original fuel piping system and the modifications foreseen at a later stage	I
	27	Schematic diagram and arrangement of the ammonia (liquid and vapour) piping systems, including venting systems	A
	28	Arrangement of the venting mast	A
B		For boil-off gas management (tanks other than fully pressurized type C tanks) see [8]:	
	29	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	I
	30	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)	A
(1) A: document to be submitted for approval; I: document 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 future stage are summarized in Tab 2.

Table 2 : 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/m^3)	672	422	• higher static and dynamic load on the tank structure • pumps may need to be replaced
Liquid volumetric energy density (LHV, in GJ/m^3)	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 Cp (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:
- pressurized, refrigerated or semi-refrigerated type C tanks
- refrigerated type A tanks
- refrigerated membrane 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.

For pressurized or semi-pressurized type C tanks where the capability of the pressure accumulation method is justified, one boil-off management system is to be provided.

For other types of tanks, two boil-off management systems are to be provided.

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 Sec 2, [3] and Sec 2, [6.2].

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 Sec 2, [3.1].

2.2.4 The access to spaces where ammonia may be present is to comply with the provisions of Sec 2, [3.4.2]. 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 / non-hazardous area classification of the spaces where ammonia may be present is to be defined in accordance with the provisions of Sec 2, [9].

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 initial design stage are to comply with the relevant provisions of Sec 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 Type-A or Type-C tanks associated with the use of ammonia as fuel are to be implemented at the original design stage with the aim of preventing the need for specific structural modifications at the conversion 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 Sec 2, [3.4.2].

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 Sec 2, [11], 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 Sec 2, [11]. 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 the ship conversion 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 Sec 2, [5.2].

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.

Type C tanks intended to be used with ammonia at ambient temperature are to be designed for the vapour pressure of ammonia corresponding to a temperature of 45°C.

For membrane tanks, the reinforcements necessary for the containment systems are to be implemented at initial building 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 the initial design 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 the ship conversion 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 the design 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 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 (see Sec 2, [4.3.10]).

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 the ship conversion 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 the ship conversion 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.

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