H2 (Jan 2026) Design, construction and testing of ammonia release mitigation system (ARMS) in ammonia fuelled vessels

1 Application

1.1 The following requirements are applicable to ammonia release mitigation systems (ARMS) for use in ammonia fuelled vessels other than ships subject to the IGC Code.

2 Functional requirements

2.1 The ARMS referred in this UR are one of the systems to treat ammonia releases quoted in the Interim Guidelines for the Safety of Ships Using Ammonia as Fuel[1] paragraph 5.2.1.2 as “recovery system” or “treatment system”.

2.2 The ARMS is to comply with the provisions given in paragraph 9.4.8 of the “Interim Guidelines for the Safety of Ships Using Ammonia as Fuel” when used for managing releases related to normal operation such as:

- bleed from double block and bleed arrangements on the fuel piping systems
- purging and draining operations of fuel pipes.

and also when used for managing releases related to foreseeable and controllable abnormal scenario, such as:

- releases from the opening of pressure relief valves in the fuel piping system.

Other abnormal scenarios like

- leakages from ammonia pipes into the double wall piping
- leakages from ammonia pipes into Tank connection spaces, Fuel Preparation Rooms or Bunkering Stations

shall also be safely managed according to chapter 5.

2.3 The ARMS discharge outlet is to be provided with ammonia detection.

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1 MSC.1/Circ.1687

Note:

1. This Unified Requirement is to be uniformly implemented by IACS Societies on ships contracted for construction on and after 1 July 2027.

2. The “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR) No. 29.

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2.4 In case an ARMS is used for the treatment of uncontrollable releases of ammonia or in emergency situations, it is not required to comply with the provisions in paragraph 9.4.8 of the Interim Guidelines For The Safety Of Ships Using Ammonia As Fuel.

2.5 The ARMS is to be ready to treat ammonia releases when starting using ammonia as fuel and is to be kept in such condition until the fuel supply system is purged of ammonia after normal and emergency shut down.

2.6 For ships where ammonia is the only fuel for systems providing services that are essential for the safety of the ship, the ARMS system is to be designed with redundancies such that a single failure of an ARMS component will not lead to reduction of availability of the ARMS.

This is to be demonstrated by suitable failure analysis (FMEA). See also 3.1.1.

2.7 Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation of ARMS. In case of ARMS shutdown or malfunction, an alarm is to be given in a permanently manned control station, for the crew to evaluate the situation and decide whether the consumers should be changed to another fuel.

2.8 The fuel change over philosophy in case of abnormal scenarios of the ARMS shall be evaluated in the risk assessment required in the Interim Guidelines For The Safety Of Ships Using Ammonia As Fuel.

2.9 Maintenance manuals of the ARMS are to be made available on board by the designer.

2.10 Safety philosophy is to be documented by the designer to the Classification Society.

3 Design and Arrangement requirements

3.1 General requirements

3.1.0 The ARMS is to be approved and certified by the Classification Society.

3.1.1 A risk assessment as detailed in Section 4.2 of the Interim Guidelines For The Safety Of Ships Using Ammonia As Fuel, is to be performed and is to cover the risks arising from use of ARMS affecting the person on board, and the ship. In particular, consideration is to be given to the hazards associated with toxicity, flammability, corrosiveness of ammonia gas and ammonia effluent.

3.1.2 The number and type of ARMS installed is to be of adequate combined capacity and performance to ensure that the ammonia vapour released during all normal operations and foreseeable and controllable abnormal scenarios does not exceed the concentration limits mentioned in paragraph 2.2.

3.1.3 When the ARMS is located in an enclosed space, it is to be arranged in accordance with the following:

1) The space is to be provided with an effective mechanical forced ventilation system of extraction type. A ventilation capacity of at least 30 air changes per hour is to be provided. The space shall have independent ventilation systems to eliminate the possibility of toxic gases spreading to other spaces. The number and power of the ventilation fans shall be such that the capacity is not reduced by more than 50%, if a fan with a separate circuit from the main switchboard or emergency switchboard or a

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group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

2) Permanently installed ammonia vapour detectors are to be fitted in the space. A visible local alarm shall be given in way of the entrance to the ARMS space in case the vapour concentration inside the space exceeds 25 ppm. The detection system shall be of a continuous type.

   An audible and visible alarm is to be activated on the navigation bridge, in a continuously manned central control station and inside the ARMS space at a vapour concentration of 110ppm in the ARMS space.

3) Bilge system of the space is to be segregated from the bilge system of spaces where ammonia cannot be present.

4) Ingress and egress arrangements from the space shall be designed and constructed to ensure safe access such as to allow entry to the space by personnel wearing protective clothing and breathing apparatus and shall also allow for the evacuation of injured and/or unconscious personnel.

5) The space containing any ARMS shall be considered as a Toxic space and Hazardous Area Zone 1 and therefore:

   - access to the space is to be from open deck or through an airlock and
   - Any electrical equipment fitted inside the space shall be suitably certified.

3.1.4 When ammonia effluents from the ARMS are stored in a holding tank, the tank is to be arranged in accordance with the following:

1) The holding tank is not to be installed in machinery spaces of category A.
2) The holding tank vents outlets are to comply with the provisions of the “Interim Guidelines for the Safety of Ships Using Ammonia as Fuel”.
3) Arrangements shall be provided to ensure that the ammonia concentration at the vent outlet of the holding tank is maintained below the limit stated in paragraph 2.2 of this UR , i.e. 110 ppm.
4) The holding tank is to be separated from adjacent spaces by cofferdams except in respect of boundaries with toxic spaces, ballast tanks or open spaces.

3.1.5 All materials intended for use in anhydrous ammonia systems are to be suitable and comply with regulation 17.12 of IGC Code. Materials in contact with ammonia effluent are to be compatible for such use.

3.1.6 The piping system used for the ammonia transfer to the ARMS is to be in accordance with the requirements of the ammonia fuel piping system.

3.1.6bis Ammonia effluent piping is to be subject to pressure tests for Class I as specified in UR P2.

3.1.7 The provision in 3.1.6. need not be applied for ammonia transfer pipes located in spaces regarded and arranged as fuel preparation rooms.

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3.1.8 It shall be possible for the ARMS to be manually controlled from a local position and from a safe remote position outside toxic areas/spaces.

3.2 Specific requirements

Specific requirements for typical ammonia release mitigation systems are shown in 3.2.1 to 3.2.4. However, the measures of mitigation are not limited to these.

3.2.1 Ammonia vapour dissolution tank

3.2.1.1 Design

The material used for the fabrication of the dissolution tank and any associated piping is to be selected based on the corrosive nature of the liquid media.

When designing the capacity of the ammonia vapour dissolution tank, the solubility of ammonia at different working temperature shall be considered, taking into account IACS UR M40 and the available space conditioning system.

The ammonia vapour dissolution tank is to be provided with means to prevent icing in the tank under normal operation.

If neutralization acid is to be used for mixing into water in the ammonia dissolution tank, the Risk Assessment required in 3.1.1 is to address this aspect.

3.2.1.2 Alarms, monitoring and control

Indications of parameters necessary for the safe and effective operation of the ammonia vapour dissolution tank as follows are to be provided at the local and remote control stations.

As a minimum, the following are to be provided:

- Liquid level
- Temperature
- pH value
- Pressure (except for vented tanks)

Visual and audible alarms are to be given when the liquid level, pressure values, temperature and the margin to saturation exceed given thresholds established by Designers.
Shutdown values shall be determined by Designers.

3.2.1.3 Arrangement

When by-pass arrangement and other arrangements to segregate the ARMS from the ammonia fuel supply system are being proposed for enabling maintenance operations of the ARMS while the ammonia fuel supply system is in use, acceptance of the arrangement is to be considered on the basis of the outcome of the risk assessment, taking into account possible failures of the arrangement and relevant consequences on the safety of the personnel and the ship.

3.2.2 Ammonia vapour scrubber system

3.2.2.1 Design

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The material used for the corrosive scrubber washwater is to be selected based on the corrosive nature of the liquid media. The sections of the scrubber that are subjected to washwater (e.g. the interior reaction chamber or washwater piping/nozzles, etc.) are to be constructed of suitable corrosion resistant materials.

The capacity of the pump for the scrubber is to be sufficient for the flow rate to meet the criteria stated in 2.2. The flow rate can be determined either by means of direct measurement, or by using a calculation-based methodology (computational fluid dynamics or other equally scientifically established empirical formulae). A report including all details of the flow rate analysis is to be submitted to the Classification Society.

Where washwater is supplied from a tank on board, the amount of washwater is to be sufficient for relevant ammonia vapour release scenarios. The quantity of water shall be in addition to any other amount of water needed to maintain the ship in normal operations conditions. Detailed justification of the amount of water shall be provided to the Classification Society.

The pump for the scrubber is to be operated continuously when ammonia is being supplied to the consumers or is to start automatically upon specific parameters exceeding predetermined thresholds in order to ensure that untreated ammonia is not released. The pump activation concept is to be provided to the Classification Society for information.

3.2.2.2 Alarms, monitoring and control

Activation of the system is to give an audible and visual indication at the local control station, on the navigation bridge and in a continuously manned central control station.
Indications of parameters necessary for the safe and effective operation of the ammonia vapour scrubber systems are to be provided at the local and, as applicable, remote control stations, as per the following Table:

Table. 1

Parameter	Display	Alarm	Automatic Safety Action
Ammonia vapour concentration in the inlet and outlet	X		
Ammonia vapour detection in the outlet exceeding the limits required in 2.2		X	Change over to using another fuel
Ammonia vapour detection in the inlet			Scrubber Pump start
Ammonia effluent tank level	X	High	Effluent to be transferred to ammonia holding tank
Wash water level in scrubber	X	High	
Power supply failure of alarms, monitoring and control.		X	

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3.2.2.3 Arrangement

If the Washwater supply systems is part of the fire main system, then the required fire pump capacity and working pressure are to be sufficient for both operation of ammonia vapour scrubber systems and the operation specified in 11.4.1 of the IGF Code simultaneously.

Where ammonia vapour scrubber systems are installed with bypass arrangement, the closing devices are to be fitted with interlock to prevent the closing of both the ventilation duct of ordinary use and the duct or pipe leading ammonia vapours to ammonia vapour scrubber systems. The position of damper is to be fail to safe and indicated at local and control station, and when ammonia is detected, the position of the closing devices is to automatically adapt so as to lead ammonia gas to ammonia vapour scrubber systems with alarm.

3.2.3 Ammonia combustion unit (ACU)

3.2.3.1 Design

Ammonia combustion units are to be approved by the Classification Society.
The capacity of the ACU is to be sufficient to meet the criteria stated in 2.2.

3.2.3.2 Alarms, monitoring and control

Safety systems and alarm systems of ammonia combustion units are to be in accordance with the following (1) and (2).

(1) Safety systems are to be provided so that ammonia supplies to all burners are cut off to stop the operation of the combustor when the following (a) to (h) occur during ammonia burning or oil/ammonia burning.

a. when automatic ignition fails;
b. when all flame detectors issue flame-fail signals (in such cases, it is to be able to stop the supply within 4 seconds after flame-fail);
c. when a fan supplying air for either combustion or cooling stops (excluding cases where a standby fan automatically switches on when an operating fan stops);
d. at low-low ammonia vapour supply pressure ;
e. at low-low oil fuel (pilot fuel) supply pressure;
f. when the automatic double block and bleed valves for ACU fail;
g. when the master valves for ACU close;
h. when the power supply for burner control fails.

(2) Means are to be provided to issue alarms in the following (a) to (e) cases:

a. when one of the flame detectors issues a flame-fail signal;
b. when either the combustion or cooling air supply decreases;
c. at low ammonia vapour supply pressure;
d. when the power supply for burner control fails;
e. At low oil fuel (pilot fuel) supply pressure.

Activation of the system is to give an audible and visual indication at the local control station, on the navigation bridge and in a continuously manned central control station.

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3.2.3.3 Arrangement

Ammonia combustion units may be located in a gas safe machinery space, subject to proper justification and risk assessment showing that a single failure within the combustion units including ammonia vapour transfer systems including the equipment required to control temperature, pressure, flow rate, etc. for proper combustion of ammonia, will not lead to ammonia release into the machinery space.

3.2.4 Ammonia vapour dilution system

3.2.4.1 Design

The dilution of ammonia vapour is to be accomplished by supplying sufficient dilution air into the bleed/vent/discharge piping before the ammonia is released, by using additional supply fans, or by dilution with nitrogen or other inert gas.

Fans used for the ammonia vapour dilution system are to be non-sparking according to UR F29, except where it is demonstrated that the ammonia / air mixture is not flammable, whatever the release scenario.

The vapour dilution system can be a stand-alone system, or arranged in conjunction with other ARMS systems, for a combined compliance with the requirements.

The fans for ammonia vapour dilution system are be operated continuously when ammonia is being supplied to the consumers or are to start automatically upon specific parameters exceeding predetermined thresholds, in order to ensure that untreated ammonia is not released. The fan activation concept is to be provided to the Classification Society for information.

3.2.4.2 Alarms, monitoring and control

Activation of the system is to give an audible and visual indication at the local control station, on the navigation bridge and in a continuously manned central control station.

4 Test requirements

4.1 General requirements

4.1.1 Function and performance test programs are to be submitted to the Classification Society for review before proceeding with the tests.

4.1.2 The ARMS is to be tested by the manufacturer in presence of a Classification Society surveyor unless an alternative certification scheme according to UR Z 26 is in place.

4.1.3 Upon satisfactory outcome of Workshop test the ARMS is to be provided with a Product Certificate issued by the Classification Society.

4.2.1 Ammonia vapour dissolution tank

4.2.1.1 Workshop tests

All the ammonia systems shall be tested as per Class Rules applicable to piping, structures and pressure vessels for toxic products, as applicable.

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Ammonia effluent piping is to be subject to non-destructive testing of welds and hydrostatic tests for Class I as specified in the UR P2.

Function tests are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

4.2.1.2 Onboard tests

Ammonia effluent piping is to be subject to pressure tests for Class I as specified in the UR P2.

Function tests including testing during fuel gas trials are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

Performance tests are to be carried out to demonstrate that the criteria in 2.2 are satisfied

4.2.2 Ammonia vapour scrubber system

4.2.2.1 Workshop tests

The weld joints on scrubber body are to be subject to liquid penetrant testing (PT) or equivalent testing. Ammonia gas pipe and wash pipe joints on scrubber are also to be subject to liquid penetrant testing or equivalent testing.

Ammonia effluent piping is to be subject to non-destructive testing of welds and hydrostatic test for Class I as specified in UR P2.

Scrubber system components subject to internal pressure are to be tested to a hydrostatic pressure of 1.5 times the design pressure.

Scrubber pumps are subject to capacity tests at design condition.

Function tests are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

4.2.2.2 Onboard tests

Ammonia effluent piping is to be subject to pressure tests for Class I as specified in UR P2.

Function tests including testing during fuel gas trials are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

Performance tests are to be carried out to demonstrate that the criteria in 2.2 is satisfied.

4.2.3 Ammonia combustion unit

4.2.3.1 Workshop Tests

Tests of welds in piping systems and auxiliaries of ammonia combustion unit are to comply with relevant requirements of the Class Rules.

Tests of auxiliaries and piping of ammonia combustion units after manufacture are to comply with the requirements of the Class Rules.

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Function tests are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

Performance tests of burners up to the maximum nominal capacity are to be conducted using ammonia vapour. Workshop tests using only oil fuel, however, may be accepted in cases deemed appropriate when the burners are of the same or similar type as burners which have passed a prototype test in accordance with a test program approved by the Classification Society.

4.2.3.2 Onboard tests

Function tests including testing during fuel gas trials are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

4.2.4 Ammonia vapour dilution system

4.2.4.1 Workshop tests

Function tests are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems according to manufacturer instructions.

4.2.4.2 Onboard tests

Function tests are to be carried out to demonstrate satisfactory operation of systems including associated control/alarm and safety systems.

Performance tests up to the maximum nominal capacity are to be carried out to demonstrate that the criteria in 2.2 are satisfied.

5 Ammonia releases in enclosed spaces/ secondary barriers

Leakages into fuel preparation spaces, tank connection spaces, bunkering stations or double wall piping are regarded as not controllable and therefore are not required to be handled by an ARMS.

The ammonia release at the ventilation outlets shall be managed to ensure the safety of persons on board. The dispersion analysis required by Interim Guidelines [12bis 4.3] will show whether the concentration/flow at the ventilation outlets needs to be lowered in case of a probable maximum leakage scenario in the space, to reduce the ammonia concentration in the locations where people can be present, including life-saving appliances, emergency escapes, air intakes, outlets and other openings into the accommodation, service and machinery spaces, control stations and other non-toxic spaces.

Examples of systems expected as being suitable to reduce the concentration/flow at the ventilation outlet are:

- Water mist system at the suction point of the exhaust ventilation from the space;
- Water spray at the ventilation outlet from the space;
- Water mist systems inside the space
- Reduced/stop mechanical ventilation

Water spray systems are not to be installed inside the space, unless arrangements are made to ensure that the space only contains ammonia vapours when the system is activated.

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Water mist is intended as defined in NFPA 750 Par. 3.3.24.

Strategies using water mist based systems inside the space shall be arranged to avoid vacuum effects in the space and interaction between liquid ammonia and water in case of broken nozzle or other situations where water may accumulate.

Draining of any liquid ammonia spill and increasing the ventilation rate may be capable of limiting the ammonia vapour concentration in the space, and can therefore be regarded as an effective mean to also reduce the concentration at the ventilation outlet.

Other solutions for controlling the ammonia concentration from leakages in the ammonia systems can be considered in the risk assessment.

The effectiveness of the proposed system is to be demonstrated in the context of the risk assessment.

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