Regulations of 27 December 2016 No. 1883 on ships using fuel with a flashpoint of less than 60°C

Legal basis: Laid down by the Norwegian Maritime Authority on 27 December 2016 under the Act of 16 February 2007 No. 9 relating to ship safety and security (Ship Safety and Security Act) sections 2, 6, 9, 11, 21, 28a, 29, 30 and 45, cf. Formal Delegation of 16 February 2007 No. 171, Formal Delegation of 31 May 2008 No. 590 and Formal Delegation of 19 August 2013 No. 1002.
EEA references: The EFTA Surveillance Authority (ESA) has been notified of the Regulations pursuant to the requirements of Act of 17 December 2004 No. 101 on European notification of technical rules (EEA Hearing Act) and the EEA Agreement Annex II Chapter XIX point 1 (Directive 98/34/EC as amended by Directive 98/48/EC).
Amendments: Amended by Regulation of 4 December 2019 (in force on 1 January 2020), 7 November 2023 No. 1815 (in force on 1 January 2024).

Part A

Chapter 1 Scope of application and general provisions

Section 1 Scope of application

The Regulations apply to Norwegian ships and vessels using fuel with a flashpoint of less than 60°C, when such ships and vessels are required to have:

a) vessel instructions;
b) trading certificate;
c) Passenger Certificate;
d) Passenger Ship Safety Certificate (EU) Class B, C and D;
e) High-Speed Craft Safety Certificate;
f) Passenger Ship Safety Certificate (EU) Class A;
g) Cargo Ship Safety Construction Certificate;
h) Passenger Ship Safety Certificate.

The Regulations do not apply to cargo ships which are constructed or adapted and used for the carriage in bulk of the liquid products listed in chapter 19 of the IGC Code and which use the cargo as fuel.

Vessel means fishing vessel or high-speed craft.

Section 2 Technical and operational requirements

Ships and vessels shall satisfy a recognised classification society's rules for ships using fuel with a flashpoint of less than 60°C.

IMO Res. MSC.391(95) "International Code of Safety for Ships using Gases or other Low-flashpoint Fuels", as amended by IMO MSC.422(98), MSC.458(101) and MSC.475(102), shall apply as regulation for ships or vessels required to hold a certificate as referred to in section 1 first paragraph (a) to (e):

a) for which the building contract is placed on or after 1 January 2017;
b) in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2017;
c) which are delivered on or after 1 January 2021;
d) which on or after 1 January 2017 are modified to use fuel with a flashpoint of less than 60°C.

Ships and vessels delivered before 1 January 2021 shall satisfy the requirements of IMO Res. MSC.285(86) "Interim guidelines on safety for natural gas-fuelled engine installations in ships" or the requirements of part B of these Regulations if:

a) the building contract was placed on or after 1 June 2009, but before 1 January 2017; or

b) in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 December 2009, but before 1 July 2017.

Ships and vessels delivered before 1 January 2021 shall satisfy the requirements of Part B of these Regulations if:

a) the building contract was placed before 1 June 2009; or
b) in the absence of a building contract, the keels of which were laid or which were at a similar stage of construction before 1 December 2009.

Ships to which the provisions of the third or fourth paragraph of this section are applicable shall also satisfy the requirements of part C of these Regulations.

Amended by Regulation of 4 December 2019 (in force on 1 January 2020), 7 November 2023 No. 1815 (in force on 1 January 2024).

Section 3 Accepted equipment

Equipment constituting or forming a part of the tank or fuel system shall be accepted. Accepted equipment means equipment accepted by the Norwegian Maritime Authority based on approval or type-approval from:

a) a recognized classification society;
b) other public or private institution;
c) the administration of a State that has ratified the International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974), as amended.

Section 4 Documentation

Documentation required pursuant to these Regulations is additional to other documentation required pursuant to current applicable lists of documentation laid down by the Norwegian Maritime Authority.

For ships classed in a recognised classification society, documentation relating to the requirements of these Regulations shall be approbated by the applicable classification society prior to submission to the Norwegian Maritime Authority.

For unclassed ships, documentation relating to the requirements of these Regulations shall be submitted to the Norwegian Maritime Authority.

The Norwegian Maritime Authority may require supplementary documentation and practical tests as basis for verifying that technical arrangements and systems satisfy the requirements of these Regulations.

Part B
Chapter 2 Functional requirements and requirement for risk analysis

Section 5 Functional requirements

An explosion in any area with a potentially explosive atmosphere (in the following called "hazardous area") shall not:

a) damage accommodation in such a way that passengers or crew are harmed;
b) cause damage to any space other than the space in which the explosion occurs;
c) damage the ship in such a way that ingress of water occurs below the main deck, either by direct or progressive flooding;
d) render fire-fighting equipment outside the space damaged by the explosion inoperative;
e) damage equipment or systems in other areas that may affect the ship's propulsion or power supply;
f) damage life-saving appliances and associated launching arrangements.

On passenger ships, all equipment related to the gas installation on board shall be designed to withstand a load corresponding to the ship at 2/3 of its operational speed hitting an unyielding object head on, which extends vertically along the entire height of the ship, without resulting in consequential damage on board due to a gas discharge.

Passenger ships shall upon impact be able to withstand kinetic energy of not less than:

$$E = \tfrac{1}{2}(\Delta+m)v^2$$

where:

Δ = the ship's displacement, in tonnes, as mean value of lightship weight and displacement when fully immersed

m = additional mass, in tonnes, for ships due to trailing masses of water, equals to 0.1Δ.

v = speed at time of collision, in metres per second, equals 2/3 of operational speed, minimum 10 knots (5.1 m/s).

In order to estimate the forces to which the gas installation will be exposed, calculations shall be prepared that show the passenger ship's deformation length upon impact. The calculations shall be submitted to the Norwegian Maritime Authority.

On passenger ships, the gas installation shall be designed to withstand a sideways impact corresponding to 2g.

On cargo ships, critical components of the gas and control system and gas storage tanks, generators and other heavy components of the gas system, shall have such dimensions and foundations as to withstand a longitudinal retardation of 2g.

For ships with a High-Speed Craft Safety Certificate, the gas installation shall be designed to withstand accelerations as described in chapter 4 of the International Code of Safety for High-Speed Craft, adopted by Resolution MSC.97(73) (2000 HSC Code), as amended.

A propulsion engine shall withstand the stress to which it is subjected upon changing from full speed ahead to full speed astern.

Section 6 Risk analysis

The safety level for ships using fuel with a flashpoint of less than 60°C shall be equivalent to the safety level for a new diesel-powered ship. The safety level shall be documented by a risk analysis based on and performed in accordance with recognised methods.

The risk analysis pursuant to the first paragraph is carried out by identifying undesired events and assessing the likelihood of such events arising and any consequences thereof.

The risk analysis shall ensure a comprehensive safety assessment of the fuel concept and the selected solutions. The analysis shall be presented as early as possible during the planning phase.

The risk analysis for high-speed craft shall be performed with a special focus on hull strength, speed and ingress damage in the event of impact.

The risk analysis shall cover the ship's systems for use and treatment of fuel, and their influence on the ship and its surroundings in the event of an undesired event. The analysis shall include the following subanalyses as described in Appendix 1:

a) concept analysis
b) emergency preparedness analysis
c) explosion analysis.

The risk analysis may be prepared as a combined publication or as separate subanalyses.

When the ship's working language is not Norwegian, the Norwegian Maritime Authority may require the analysis to be prepared in English.

The risk analysis pursuant to the first paragraph shall be updated when changes are made to the design, equipment or operational procedures during construction or after the ship is placed in service.

Amended by Regulation of 4 December 2019 (in force on 1 January 2020).

Chapter 3 Arrangements and design

Section 7 Classification of hazardous areas

The following hazardous areas on board are classified as Zone 1:

a) tank spaces / cold box
b) ventilation shafts
c) bunkering stations.

The following hazardous areas on board are classified as Zone 2:

a) gas engine rooms.

Other areas on board are classified in each individual case.

A drawing showing the classification of hazardous areas shall be submitted to the Norwegian Maritime Authority.

Section 8 Access

Unauthorised persons shall be prevented by physical means from accessing hazardous areas or equipment and arrangements that are connected to the gas system.

Access to the collecting unit from bunker tanks shall so designed as to prevent access during normal operation.

There shall be no direct access to hazardous areas from accommodation spaces.

If access to hazardous areas is via an engine room that is not classified as hazardous, but has auxiliary equipment and potential electrical ignition sources, the access shall be safeguarded with a gas-lock with self-locking doors.

Section 9 Gas engine rooms

Gas engine rooms shall be so designed as to minimise the damage to the space and equipment placed in the space in the event of an explosion.

If the ship has two or more gas engines for propulsion with associated control systems, and engines and systems for power generation with associated distribution and wiring, they shall as a main rule be placed in separate spaces.

Gas engine rooms shall be constructed with explosion pressure relief leading to a safe area where people or equipment cannot be harmed in the event of an explosion. Explosion pressure relief to adjacent spaces may be accepted.

Gas engine rooms shall be planned with a minimum of electrical equipment. Auxiliary systems such as pumps, etc. that are connected to gas engines and that do not require placement in the gas engine room, shall be located in non-hazardous areas.

Auxiliary systems where gas may leak directly into the system medium shall be safeguarded against gas leaks and fitted with a gas alarm.

Mechanical devices other than those required for the gas engines and the associated shaft systems shall not be installed in gas engine rooms.

Bulkheads, hulls and decks in gas engine rooms, and any explosion ducts and pressure relief spaces, shall be designed for the maximum explosion pressure that could arise for the solution in question according to the explosion analysis.

The design overpressure that the gas engine room shall withstand, shall be determined on the basis of the explosion analysis. The analysis shall take the gas engine room's geometry, design, explosion pressure relief and air-gas mixture ratio into account.

Section 10 Emergency source of power

The required emergency source of power shall be capable of simultaneously serving:

a) the controls for the gas ventilation arrangement;
b) ventilation of hazardous areas.

Section 11 Tank spaces and bunker tanks

With the exception of safety valves, it shall be possible to close all inlet and outlet valves on bunker tanks from the control room, the bridge and locally. Disruptions of the control system shall trigger an alarm. In the event of an emergency shutdown, the gas piping system shall be depressurised to the gas mast.

Bunker tanks for compressed gas shall be physically protected against overfilling by an early warning alarm for pressure. The maximum filling pressure shall:

a) trigger an alarm;
b) automatically close the filling valves;
c) provide pressure relief to the gas mast.

The maximum filling shall not exceed the maximum filling pressure set out in accordance with recommendations from the gas supplier and the classification society.

Bunker tanks for liquid gas shall be protected against overfilling by an early warning alarm and an alarm for maximum level. The maximum level shall not exceed 95% of the tank volume. Filling to the maximum level shall trigger an automatic closing of the filling valves as well as provide pressure relief to the gas mast. The automatic shutdown system shall be so arranged that it is always operative when the tank is being filled.

The early warning alarm and shutdown system for bunker tanks for compressed or liquid gas shall be independent of each other.

It shall be possible to empty, purge and vent bunker tanks and associated gas piping systems and valves.

When one tank system is non-operational, the other tank systems shall have sufficient capacity for the supply of power to the ship and for propulsion to a port.

Bunker tanks shall be placed as close as possible to the centreline.

Gas storage tanks placed in or below an area for cargo-handling operations shall have protection that reduces the risk of damage to the gas storage tank.

Section 12 Bunkering stations

The bunker manifold shall have a remote-controlled valve arrangement, cf. section 11 second paragraph.

The bunkering system shall be protected against operator errors during bunkering. This shall be documented in the risk analysis as required by section 6.

The bunkering station shall be physically shielded from accommodation, cargo/working deck and control stations.

Connections and piping shall be so positioned and arranged that damage to the gas piping does not cause damage to the ship's gas storage tank arrangement leading to uncontrolled discharge of gas.

Bunkering hoses, transfer equipment, pipes and connections shall be so arranged and equipped that electric potential is equalised.

Section 13 Ventilation

The ventilation shall function at all temperatures in which the ship will be operating.

The ventilation system for hazardous spaces shall be separated from the other ventilation on board.

Air intakes and outlets in hazardous spaces shall be placed at a distance preventing mixture of the airflows.

The ventilation capacity for gas engine rooms shall be at least 30 air changes per hour of the room's gross volume. Ventilation failure, reduced air circulation and operational errors shall trigger an alarm.

The ship's control stations shall be warned of operational and functional defects in the mechanical ventilation of the collecting unit from bunker tanks and ventilation shafts. The alarm shall apply to fans and airflow.

There shall be negative pressure ventilation in all hazardous spaces. When the gas engine room is located above the main deck, positive pressure ventilation may upon application be accepted as an equivalent solution.

The air intake in all hazardous technical rooms shall have replaceable filters.

Ventilation ducts to and from hazardous spaces shall be designed to withstand the maximum pressure build-up in the event of a design explosion event, cf. section 9 final paragraph.

Non-hazardous machinery spaces, generator rooms and control panel rooms shall have positive pressure ventilation with an air supply from a gas-safe area. Assessments shall be made to determine whether non-hazardous spaces adjacent to hazardous spaces shall be provided with ventilation. Ventilation failure shall trigger an alarm.

Section 14 Gas piping arrangement

Ships with one gas engine room shall have two separate supplies of fuel to gas engines placed in the gas engine room.

On passenger ships, the fuel supply to gas engines shall be carried in double piping in gas engine rooms. Other solutions for the fuel gas piping arrangement, which is part of the gas engine's fixed arrangement, may be considered by the Norwegian Maritime Authority in each individual case.

Gas piping shall not be led through other engine rooms. When double gas piping without discharge sources is used, and the danger of mechanical damage is negligible, gas may be led through another engine room when the room is equipped with a gas alarm.

Gas piping with valve arrangements shall be positioned at least 760 mm from the ship side.

Gas piping shall be protected against mechanical damage and the piping shall be capable of assimilating thermal expansion without developing substantial tension.

Section 15 Gas detection systems

All spaces that are defined as hazardous shall be monitored by a fixed gas detection system. The gas detection system shall be type-approved, accepted for hydrocarbon gas and for use in hazardous spaces.

The number and location of the gas detectors shall be assessed by the Norwegian Maritime Authority in each individual case. The size, gas sources and ventilation of the hazardous space will form part of the assessment. A combination of line detectors and point detectors may be used in the same room.

Gas detectors located in the exhaust duct for the engine-room ventilation shall have alarm limits of maximum 5% and 10% of the Lower Explosion Limit (LEL). Alarm limits of 5% and 10% of the LEL may also be considered in other locations where the air exchange ratio is high and where a quick dilution of the gas concentration can be expected. Other gas detectors shall have alarm limits of maximum 20% and 40% of the LEL.

Section 16 Gas engines, regulation and control

If the gas engine room ventilation is non-operational, the engine's control system shall prevent the engine from starting. A manual override of the engine-start lockout shall be possible.

It shall be possible to manually trigger the emergency shutdown of each individual gas engine as well as the shutdown of the gas supply to gas engine rooms from the bridge, control room and locally near the gas engine room.

Gas engines shall safeguarded against reignition after the shutdown of the gas supply.

Gas engines shall be fitted with a rev limiter.

Section 17 Fire protection

Gas engine rooms shall be fitted with a fixed primary water-based extinguishing system. It shall be possible to activate the system from the bridge, control room and locally from a safe location outside the gas engine room.

Bulkheads and decks surrounding hazardous spaces and ventilation ducts leading to such spaces shall be insulated to a fire integrity of A-60.

Section 18 Electrical systems

Generators in hazardous spaces shall be brushless and insulation monitored by alarms in the event of earth faults.

Communication equipment and other fixed, handheld or portable electrical equipment in hazardous areas shall be explosion protected (Ex-protected) pursuant to the recommendations of IEC-60079-14 with regard to the nature of protection, temperature class and gas group for the zone and gas type in question. The equipment shall be adapted to the exterior environmental conditions to be expected. The ingress protection degree (IP) for generators shall comply with the supplier's recommendations for the area or location in question. Water-cooled generators shall have minimum IP 44. Air-cooled generators shall have minimum IP 22.

When transferring a flammable gas or liquid, there shall be an equalisation connection between the bunker supplier and the bunkering station on the ship.

Cable penetrations shall satisfy the requirements regulating the dispersion of gas.

Chapter 4 Testing and control of gas-related equipment and arrangements before the ship is placed in service

Section 19 General provisions

The company shall document that all requirements of this chapter are satisfied before the ship is placed in service.

The company shall have procedures for inspection and testing of all systems on board. The procedures shall include a plan for an 80-hour long-term test of equipment and arrangements that have not undergone a factory acceptance test in accordance with the rules of a recognised classification society. The data from the long-term test shall be submitted to the Norwegian Maritime Authority.

All technical gas-related equipment and all arrangements shall be tested in accordance with specifications set out in drawings documentation and manuals.

Section 20 Gas engine testing

The following functions and procedures for the gas engine system shall be tested on board:

a) engine-start lockout initiated by a ventilation stop in the engine room,
b) other safety functions for the gas engine systems and their arrangements.

On ships with redundant engine rooms, tests shall be carried out demonstrating that each engine room can maintain manoeuvrability, ventilation and power generation.

"Black out" tests and the tests of the machinery's ability to withstand maximum load changes shall be carried out. The tests shall be performed for each individual engine and in the relevant operational modes.

The machinery's regulating control capability at low loads shall be tested to verify critical levels.

A "crash stop" test, changing from full speed ahead to full speed astern, cf. section 5 eighth paragraph.

Section 21 Bunker tanks

Tanks and the associated gas piping and valve arrangements shall be tested for tightness before they are filled with gas.

Pressure control valves and pressure relief valves shall be tested.

Emergency shutdown initiated by the maximum permitted filling of bunker tanks shall be tested.

Valve operations for the shutoff of fuel and venting shall be tested.

Bunker tanks shall be pressure-tested with water and dried out with hot air or hot nitrogen before they are placed in service.

Bunker tanks for liquid gas shall be cooled with nitrogen filling before the first bunkering.

Section 22 Gas piping

All gas piping shall be tested for tightness with an inert gas.

Section 23 Bunkering station

At liquid gas facilities, the bunkering station's connections and valve arrangements shall be tested by filling of liquid nitrogen according to the supplier's procedures.

In addition to the tests pursuant to the first paragraph, the following shall be performed:

a) tightness testing at actual temperatures,
b) testing of overfilling protection,

c) testing of emergency shutoff valves in the event of interrupted filling and emptying of bunker tanks and purging of gas.

Section 24 Ventilation

The requirements for testing and control of ventilation apply to all hazardous spaces.

The design of the ventilation system shall be tested to check that gas pockets cannot form.

The ventilation capacity shall be measured and controlled.

The ventilation system's interlocking functions in relation to the engine systems and engine rooms shall be tested.

Section 25 Gas detection system

The gas detection system shall be tested by exposing each individual detector to calibration gas, and by verifying that data has been registered on the right channel and with the right concentration level.

Section 26 Thermal imaging of electrical systems

The Norwegian Maritime Authority may require thermal imaging of electrical systems before they are put in service.

Part C
Chapter 5 Operation and maintenance

Section 27 Procedures

Ships shall have procedures that cover the safety aspects of the vessel's ordinary operation, for instance during navigation, in ports, during bunkering, at bases, oil installations and oil fields, and in repair yards.

For ships not required to hold a safety management certificate, the bunkering procedure shall be submitted to the Norwegian Maritime Authority.

Procedures for purging of gas shall be prepared. Purging of gas that takes place at a shipyard shall be performed in accordance with procedures prepared in collaboration with the shipyard.

Section 28 Maintenance

A maintenance manual for the gas supply system shall be available on board.

The manual as required by the first paragraph shall include maintenance procedures for all technical gas-related installations. The manual shall comply with recommendations from the suppliers of the equipment used in the gas supply system. The intervals for and the extent of replacement or recertification of the gas valves shall be established.

The maintenance procedure shall specify who is qualified to carry out the maintenance.

A special maintenance manual shall be prepared for electrical equipment that is installed in hazardous spaces and areas. The inspection and maintenance of electrical installations in hazardous spaces shall be performed in accordance with EN 60079-17.

Personnel carrying out inspections and maintenance of electrical installations in hazardous spaces shall be qualified pursuant to IEC 60079-17.

Section 29 Special provisions for maintenance and repair work

Engine-start lockout initiated by a ventilation stop in the engine room and other safety functions for the gas engine system shall be tested regularly in accordance with the recommendations from the equipment suppliers.

A function test of the gas detection system and test of the gas detector calibration shall be carried out in accordance with recommendations from the supplier at least once per year.

A short shutdown of the ventilation in hazardous spaces shall be carried out at regular intervals to identify minor gas leaks. Alternatively, tightness tests may be performed locally with an electronic Ex-protected measuring device.

Before maintenance work is commenced, bunker tanks and associated gas piping systems shall be emptied and purged of gas to the extent necessary.

When hot or cold work is to be carried out in hazardous spaces and areas, the gas piping system of such spaces and areas shall be purged of gas. At least two persons shall be present in the hazardous area at the same time, whereof one shall have been assigned and instructed to act as a fire watch.

The master, chief engineer officer or company shall issue a written permit for hot and cold work in hazardous areas. The permit shall include information of the time at disposal until the pressure in the bunker tanks rises to the opening pressure of the safety valves.

Inerting shall be carried out with for instance nitrogen, CO_2 or argon prior to venting. Access to the collecting unit for bunker tanks shall not be permitted until the atmosphere has been checked and determined safe.

Part D
Chapter 6 Concluding provisions

Section 30 Equivalents and exemptions

The Norwegian Maritime Authority may upon written application permit other solutions than those required by these Regulations when it is established that such solutions are equivalent to the requirements of the Regulations.

The Norwegian Maritime Authority may exempt a ship from one or more of the requirements of the Regulations when the company applies for an exemption in writing and one of the following conditions is met:

a) the company establishes that the requirement is not essential and that the exemption is justifiable in terms of safety;
b) the company establishes that compensating measures will maintain the same level of safety as the requirement of these Regulations.

Section 31 Entry into force

These Regulations enter into force on 1 January 2017. As from the same date, the Regulations of 17 June 2002 No. 644 on cargo ships with natural gas fuelled internal combustion engines and the Regulations of 9 September 2015 No. 1218 on the construction and operation of gas-fuelled passenger ships are repealed.

Appendix 1

Amended by Regulation of 4 December 2019 (in force on 1 January 2020), formerly Appendix 3.

Implementation of risk analysis for the construction and operation of ships using fuel with a flashpoint of less than 60°C

Section 1 *Guidelines*

1. The analysis is carried out through the identification of undesired events and an evaluation of the likelihood that they may arise and the associated consequences.
2. The analysis shall ensure a comprehensive and overall safety assessment of the entire gas-fuelled ship concept.
3. The analysis shall be performed in accordance with recognised procedures and methods and with up-to-date software. Guidelines for planning, performing and using risk analyses may for instance be found in the Norwegian standard NS-5814, “Requirements for risk analyses”.[1] The international standard IEC 60300-

3-9 Risk Analysis of Technological Systems provides similar guidelines. The methods described in the standards and guides are the most commonly used risk analysis methods.

4. A coordinator should be appointed, who will be responsible for follow-up and communication between the relevant parties during the preparation of the risk analysis.

1 The guide for this standard is published in SINTEF report No. STF75A91021.

Section 2 ***Method***

1. The risk analysis shall describe the methods, computer programs and the national or international standards used.

2. The data sources, data and calculations used for the preparation of the analysis shall be specified and documented.

Section 3 ***General risk analysis requirements***

The risk analysis shall be carried out by an enterprise that can document its knowledge of and experience with the performance of risk analyses, and that has knowledge of the ship's construction and technical and operational systems.

1. The risk analysis shall satisfy the requirements set forth in section 6 of these Regulations and specified in this Appendix, as well as the risk analysis requirements mentioned in other sections.

2. The analysis shall document that any gas explosion will be controlled so that people are not injured and equipment and ship are not damaged, cf. section 5 of the Regulations.

3. The scope of the analysis can be reduced if a satisfactory risk level for identical constructions and systems with the same gas type has been previously documented to the Norwegian Maritime Authority.

4. In addition to technical functional failure and similar, the element of human error shall also be included in the analysis.

Section 4 ***Subanalyses***

1. *Concept analysis*

The concept analysis shall include all the ship's gas-related arrangements and systems, their placement in relation to each other, and any redundancy. The analysis shall include a reliability/vulnerability assessment in which human error, structural limitations, functional and system failures, etc. are taken into account. Any supplier of gas installation equipment and systems on board shall be subjected to such a vulnerability analysis.[1]

The results of the entire concept analysis shall act as a guide for the selection of design solutions for ship and equipment, so that the applicable functional requirements are met. Risk-reducing and consequence-reducing measures shall only include matters relating to gas operation. The measures shall be identified and summarised in the analysis. The identification shall indicate which structural and operational measures are required to be implemented in order to achieve a level of safety that is at least as high as that of diesel-powered ships.

2. *Emergency preparedness analysis*

This analysis shall be carried out on the basis of accidents and design explosion events that may arise on board. The ship's safety functions, safety and response systems and the crew's positions and duties in an alarm situation shall be used as a basis for the emergency preparedness analysis. The emergency preparedness analysis shall set out any specific emergency preparedness measures related to gas operation. The results of the emergency preparedness analysis shall be incorporated in the ship's emergency preparedness plan.

3. *Explosion analysis*

The explosion analysis shall determine the probability of the formation of an explosive gas mixture, the probability of ignition of the gas, as well as the consequences of any explosions. The analysis shall indicate whether the ship satisfies the requirements set out in sections 5 and 6 of the Regulations. The analysis shall, *inter alia*, confirm the dimensions of explosion panels/ducts/hatches in hazardous spaces and the strength of the hazardous spaces. The maximum pressure shall be calculated on the basis of a design explosion event. The explosion pressure relief to open air or to pressure relief spaces shall be included in the calculations.

1 Guidelines for a vulnerability analysis are for instance given in the book System Reliability Theory; Models, Statistical Methods and Applications (ISBN 0-471-4713).