RULES
FOR THE CLASSIFICATION OF SHIPS

Part 11 - REFRIGERATING PLANT

2009

CROATIAN REGISTER OF SHIPPING

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By decision of the General Committee of Croatian Register of Shipping,

RULES FOR THE CLASSIFICATION OF SHIPS
PART 11 – REFRIGERATING PLANT

has been adopted on 8th May 2009 and shall enter into force on 1st July 2009

REVIEW OF AMENDMENTS IN RELATION TO PREVIOUS EDITION OF THE RULES

RULES FOR THE CLASSIFICATION OF SHIPS

Part 11 – Refrigerating plant

All major changes throughout the text in respect to the Rules for technical supervision of sea-going ships, Part 11 – Refrigerating plant, 2008 edition are shaded.

Items not being indicated as corrected have not been changed.

The grammatical and print errors, have also been corrected throughout the text of the subject Rules but are not indicated as a correction.

NOTE: *Due to change of the structure of the Technical Rules (separation of statutory from classification rules), the previously issued Rules for technical supervision of sea-going ships, Part 11 – Refrigerating plant, are now re-categorized as the part of the classification rules.*

By such change, Part 11 – Refrigerating plant, will no longer be issued as the part of the Rules for technical supervision of sea-going ships.

The subject Rules include the requirements of the following international Organisations:

International Maritime Organization (IMO)

Conventions: International Convention for the Safety of Life at Sea 1974 (SOLAS 1974) and all subsequent amendments up to and including the 2006 amendments (MSC.217/82) Protocol of 1988 relating to the International Convention for the Safety of Life at Sea 1974, as amended (SOLAS PROT 1988)

International Association of Classification Societies (IACS)

Unified Requirements (UR): M57 (1993)

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1 GENERAL

1.1 APPLICATION

1.1.1 The present part of the *Rules for the classification of ships* (hereinafter called: the *Rules*) applies to marine refrigerating plants and their equipment.

1.1.2 ***CROATIAN REGISTER OF SHIPPING*** (hereinafter referred to as *Register*) classed refrigerating plants are to comply with all requirements of this part of the *Rules*.

1.1.3 Unclassed refrigerating plants are to comply with all requirements of this part of the *Rules* specified in 1.3.2.1, 1.3.2.2, 1.3.2.5 (only for apparatus and vessels subject to the pressure of refrigerant), 1.3.2.6 (only for refrigerant systems), 1.3.2.7 (only the automatic protection systems are concerned), 1.3.4.2, 1.3.4.3, 1.3.4.5, 1.3.4.7 (only for protection systems), 1.3.4.8, 2.1.2, 2.2.2, 3.1.1, 3.1.3-3.1.9, 3.2.1-3.2.5, 3.3.4, 3.3.8, 3.3.10, 3.4.3, 3.5, 4.1.2, 4.1.5, 5.1.1, 5.1.2, 5.1.4, 5.2.1, 6.1.1, 6.1.2, 6.2.3, 6.2.5, 6.2.6, 7.1.2, 7.2.3, 7.2.4.3, 7.2.8, 8.2.3, 8.2.4, 9.1.2 (only for equipment subject to the pressure of refrigerant) 9.1.3, 9.1.6 and 9.2.1.

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to general terminology are given in *Rules, Part 1-General requirements*, Chapter 1. The following definitions and explanations for purpose of the present part of the *Rules* have been adopted:

1.2.1 **Refrigerating machinery space** – a space containing mechanical and other types of equipment intended for refrigerating plants.

1.2.2 **Refrigerated spaces** – cargo holds and spaces provided with equipment capable of maintaining the reduced temperatures and intended for the carriage of refrigerated and frozen cargoes.

1.3 SCOPE OF SUPERVISION AND TECHNICAL DOCUMENTATION

1.3.1 General provisions covering the procedure of classification, supervision during construction and classification surveys, as well as the amount of technical documents for the refrigerating plant which should be submitted to the *Register* for consideration and approval are specified in the *Rules, Part 1-General requirements*.

The technical documents for compressors and pumps which should be submitted to the *Register* for consideration and approval are specified in the *Rules, Part 9-Machines*, 1.2.3 and for heat exchangers and pressure vessels, as determined in the *Rules, Part 10-Boilers, Heat Exchangers and Pressure Vessels*, 1.3.4.1.

1.3.2 The machinery and apparatus, which are to be manufactured under the supervision of *Register* are:

.1 refrigerating compressors,
.2 refrigerant pumps,
.3 brine pumps,
.4 cooling water pumps,
.5 heat exchangers and other apparatus and pressure vessels of refrigerant, brine or cooling water,
.6 pipes and fittings intended for work with pressure of 1,0 MPa and over,
.7 devices of automatic control, indication and protection systems, as well as instruments for measuring and recording of temperature in the refrigerated spaces.

1.3.3 The parts of machinery and apparatus mentioned in 1.3.2 are to be technically supervised by *Register* during manufacture to ensure that the provisions of the *Rules, Part 25-Metallic Materials*, Chapter 1, and *Part 26-Welding*, as well as particular requirements of technical documents approved by *Register* are complied with. The parts of machinery under 1.3.2.1-1.3.2.4 are listed in the *Rules, Part 9-Machines*, Table 1.2.4, and the parts of apparatus under 1.3.2.5 are listed in the *Rules, Part 10-Boilers, Heat Exchangers and Pressure Vessels*, Table 1.3.3.

1.3.4 At the stage of ship's construction the following works are to be supervised by *Register*:

.1 manufacture and testing of relevant items of the plant at the workshop,
.2 mounting of machinery, heat exchangers and pressure vessels,
.3 mounting of refrigerant systems,
.4 mounting of secondary refrigerant, cooled air and cooling water system,
.5 mounting of the main and emergency ventilation systems,
.6 mounting of insulation in the refrigerated spaces and freezing chambers, as well as devices and refrigerating piping,
.7 installation of control, indication, alarm and protection systems of the refrigerating plant,
.8 testing of refrigerating plant.

2 GENERAL TECHNICAL REQUIREMENTS

2.1 GENERAL PROVISIONS

2.1.1 The machinery and other units of the refrigerating plant, shall remain operative under the environmental conditions specified in the *Rules, Part 7-Machinery Installations*, 1.6.

2.1.2 The machinery and equipment constituting the refrigerating plant are to be installed and fastened on board ship in accordance with the *Rules, Part 7-Machinery Installations*, 1.13.1, 1.13.4, 1.13.6 and 1.13.7.

2.2 REFRIGERANTS AND DESIGN PRESSURE

2.2.1 The refrigerants are subdivided into three groups as follows:

I – non-flammable refrigerants,

II – toxic and flammable refrigerants having low flammable level at the volume concentration of the refrigerant vapours in air of 3,5 per cent and over,

III – explosive or flammable refrigerants having low flammable level at the volume concentration of the refrigerant vapours in air of less than 3,5 per cent.

The refrigerants included in group III may be permitted by *Register* only for the refrigerant systems of ships carrying the liquefied gases in bulk with the cargo used as a refrigerant.

2.2.2 In strength calculations of the items operating under refrigerant pressure the design pressure shall be taken not less than the excessive pressure of the saturated vapours of the refrigerant at temperature +50°C in accordance with Table 2.2.2.

The refrigerating plant components working under the pressure are to be calculated for compliance with hydraulic test pressure (see 9.1.2). The stresses involved shall not exceed 0.9 times the yield point of material.

2.3 CAPACITY AND EQUIPMENT

2.3.1 Refrigerating plants are to provide effective maintenance of the temperatures in refrigerated spaces as may be required for the cargo carried, depending upon its type and conditions of area of navigation under the normal service conditions of the ship.

2.3.2 The refrigerating plant of ships of unrestricted area of navigation, with the main equipment at work, is to provide the maintenance of required temperatures in refrigerated spaces supplying cold to all consumers under the following environmental conditions:

– sea water temperature of not less than +32°C;

– ambient temperature of not less than +40°C, and relative humidity of 55%.

Design environmental conditions of refrigerating plants of the industrial ships, (fish processing and similar) which in addition to refrigerating plants of cargo holds, are provided with refrigerating facilities, shall be specially agreed by *Register* for each particular case.

2.3.3 Capacity of the main equipment of the refrigerating plant is to be sufficient to maintain the required temperatures in refrigerated spaces when working 24 hours a day.

The main equipment shall comprise at least two equal condensers and, where intermediate secondary refrigerant or cascade and stage cycles are used, two equal evaporators, intercascade heat exchangers and intermediate pressure vessels, shall be provided.

Table 2.2.2
Refrigerant design pressure

Refrigerant group	Symbol	Chemical formula	Design pressure, p - MPa	
			High-pressure side	Low-pressure side
I	R22	CHF_2Cl	2,25	1,7
	R134a	CF_3CH_2F	1,34	1,09
	R404a	mixture R134a, R125, R143a	2,5	2,03
	R407c	mixture R32, R125, R134a	2,35	1,9
	R410b	mixture R32, R125	3,3	2,68
	R507	mixture R125, R143a	2,55	2,07
II	R717	NH_3 (ammonia)	2,4	1,75
III	R290	C_3H_8 (propane)	1,6	
	R1270	C_3H_6 (propylene)	2,0	

Note:
1. It is recommended that refrigerants R12, R22 and R502 are not used in newly installed refrigerating plants onboard ships.

2.3.4 Capacity of the refrigerating plant designed also for cooling of non-precooled cargoes with all machinery at work including the stand-by unit, shall be sufficient to reduce the cargo temperature to the required temperature as quickly as necessary for preservation of that cargo.

2.3.5 Stand-by equipment of compressor refrigerating plant shall comprise one compressor with a drive motor, one condenser, control systems and all fittings necessary for independent operation of all components of this equipment.

Capacity of the stand-by equipment shall be such as to supply sufficient cold to all consumers if one of the main compressors or condensers is out of operation.

2.3.6 On the industrial ships which are, besides cargo holds refrigerating plant, provided with other facilities (for freezing, ice production, etc.), a stand-by cargo hold refrigerating plant shall be specially considered by *Register* for each particular case.

2.3.7 Freezing and cooling facilities shall provide freezing (cooling) as quickly as may be required for certain cargo.

Where cooling or freezing apparatus with a capacity in excess of 10 tons per 24 hours are provided, at least two such apparatus must be installed with total capacity equal to the required one.

2.3.8 Pipe systems between apparatus and machinery shall be jointed in such a way as to provide operation of the refrigerating units at various combinations of apparatus machinery and facilities necessary for their independent operation.

The apparatus shall be fitted with the connections for suction and delivery pipes providing the transfer of the refrigerant and its discharge from the apparatus.

2.3.9 The distribution of cooling grids is to provide uniform cooling of the space concerned.

The grids are to be arranged in not less than two independent sections, with means permitting shut-off of each section. The use of cooling grids with direct expansion of group II refrigerant is not permitted.

2.3.10 When pumping for liquid refrigerant circulation is used, at least two circulating pumps are to be fitted, one of which is to be a stand-by pump.

2.3.11 The liquid secondary refrigerant system serving a single group of cold consumers shall comprise at least two circulating pumps, one of which being stand-by.

In case of two or more groups of cold consumers with separate liquid secondary refrigerant systems differing in temperatures, each is to have at least one circulating pump. A common stand-by pump may be admitted provided it has adequate capacity and pressure head.

2.3.12 Cooling water supply to the refrigerating plant is to be provided from at least two circulating pumps, one of which is to be used for stand-by purpose.

2.3.13 Cooling water shall be supplied from at least two sea suction valves. Where it is intended to use sea valves of general service, proper structural arrangements are to be provided for adequate supply of cooling water from each sea valve under normal service conditions of the ship.

2.4 MATERIALS

2.4.1 Quality and main characteristics of materials used for manufacture of parts, assemblies and securing items of the refrigerating equipment subject to the dynamic loads, excessive pressures, variable and low temperatures are to comply with requirements of the *Rules, Part 25-Metallic Materials*, Chapter 1.

The choice of materials depends on the working temperature and physical and chemical properties of the refrigerant:

.1 materials used for the manufacture of parts of equipment exposed to the refrigerants and their solutions, lubricating oils, cooling and cooled media, shall be inert and resistant to their action;

.2 materials used for the manufacture of parts of equipment working at low temperatures shall not be subject to structural irreversible modifications and shall maintain adequate strength at the temperatures concerned;

.3 materials of elements and assemblies of refrigerating plants working at temperatures not below –50°C are to comply with requirements of the *Rules, Part 25-Materials*, 3.2 (category F), and *Part 2-Hull*, 1.4.4;

.4 materials used for the manufacture of parts of equipment working at temperatures below –50°C shall be subject to special consideration by *Register* in each case.

2.4.2 Parts of machinery and apparatus exposed to the action of corrosive agents are to be made of materials with adequate corrosion resistance or be protected by corrosion-resisting coatings.

Assemblies and parts of machinery and apparatus made of materials differing in electric potential having possibility of being exposed to the influence of sea water, are to be protected against galvanic corrosion.

2.4.3 Steel pipes and connecting pieces of refrigerant, liquid secondary refrigerant made of steel other than stainless steel are to be galvanised on the outside or treated in some other way ensuring equivalent antirust protection. Surfaces in contact with refrigerant or liquid secondary refrigerant are not to be galvanised.

In manufacturing pipes the requirements of 2.4.1 and 2.4.2 are to be taken into consideration.

2.5 ELECTRICAL EQUIPMENT

2.5.1 Electrical equipment of refrigerating plants and automatic devices as well as the lighting of refrigerating machinery and refrigerated spaces and refrigerant storerooms are to comply with adequate requirements of the *Rules, Part 12-Electrical Equipment*.

2.5.2 Driving motors of compressors, pumps and fans are to meet the requirements of the *Rules, Part 12-Electrical Equipment*, 5.7 and 5.8.

3 REFRIGERATING PLANT SPACES

3.1 REFRIGERATING MACHINERY SPACES

3.1.1 The refrigerating machinery spaces are to meet the requirements of the *Rules, Part 7-Machinery Installations*, 1.11.1, 1.11.2 and 1.11.9 as well as the requirements of this section.

Refrigerating equipment working with group II and group III refrigerants is to be arranged in isolated gastight compartments.

In case of Group II refrigerant plants of fishing vessels under 55 m in length or other Group II refrigerant plants with a quantity of Group II refrigerant not greater than 25 kg said plants are allowed to be located in the machinery space

Drainage of the refrigerating machinery space is to comply with requirements of the *Rules, Part 8-Piping*, 2.4.10.

3.1.2 The machinery, apparatus and piping are to be so arranged in the refrigerating machinery space as to permit easy access for maintenance and to enable the parts to be renewed, if necessary, without dismantling the machinery and apparatus from foundations. Care should be taken that the machinery apparatus and other equipment is placed not less than 100 mm remote from bulkheads and other vertical surfaces.

3.1.3 The refrigerating machinery space, except for small compartments, is to have two escape ways located as far apart as practicable, with the doors opening outwards. Where the refrigerating machinery space is not situated on open deck, level each of the escape ways is to be fitted with steel ladders as widely separated from each other as possible and leading to the spaces which give access to the open deck.

Compartments of automated refrigerating machinery working with group I refrigerant, where continuous watch is not required, may not be provided with a second means of escape.

3.1.4 The escape ways from spaces of refrigerating machinery working with group II and group III refrigerants are not to terminate in accommodation, public and service spaces in communication, therewith. One of the escape ways is to lead to the open deck.

Where the escape ways are located in corridors and casings, these are to be fitted with supply and exhaust ventilation. Forced air supply being obligatory. The starting arrangements of the ventilation are to be available both inside and outside the machinery space, placed in immediate proximity to the exit.

3.1.5 Compartments containing machinery of Group II refrigerant (including vessels for fish processing) are to be fitted with a fixed Group II refrigerant detector system with alarm inside and outside the compartment, at navigation bridge and at main control station.

3.1.6 At least two sets of breathing apparatus and protective clothing are to be available on the vessels with Group II refrigerant.

3.1.7 Exits from spaces housing refrigerating machinery working with group II and group III refrigerants are to be provided with water-screen arrangements. The starting means of water screens are to be available outside of the space placed in immediate proximity to the door.

In the machinery space there shall be one hydrant of the water fire system and a hose.

3.1.8 The refrigerating machinery space shall have an independent ventilation system ensuring 10 air changes per hour.

3.1.9 In addition to the main ventilation system required in 3.1.8, each refrigerating machinery space is to be fitted with emergency independent ventilation system of a capacity sufficient for:

.1 30 air changes per hour for spaces of refrigerating machinery working with group II and group III refrigerants;

.2 20 air changes per hour for spaces of refrigerating machinery working with group I refrigerant.

Capacity of the ventilation system is to be determined on the base of the total volume of the space. Other suitable arrangements which ensure an equivalent effectiveness may be considered.

Depending on density of the refrigerant, exhaust ventilation is to be provided from the uppermost or lowest parts of the space, on several places.

When calculating the emergency ventilation system, the capacity of the main ventilators may be included, provided these are operable with the emergency ones, should the switchboard of the refrigerating units be de-energised.

3.1.10 In case of refrigerating machinery of Group II refrigerant located in the machinery space, in compliance with stated in 3.1.1, third paragraph, the area where the Group II refrigerant machinery is installed is to be served by a hood with a negative ventilation system, so as not to permit any leakage of Group II refrigerant from dissipating into other areas in the space.

A water spray system is to be provided for the said area.

In addition, in this case too, the requirements from 3.1.5, 3.1.6 and 6.2.8 are to be met.

3.2 REFRIGERANT STORE ROOMS

3.2.1 Refrigerant storerooms are to be separated from other spaces. Their location in the ship and construction of boundaries, are to be in compliance with requirements of the *Rules, Part 17-Fire Protection*, 2.2 and 2.3, for storage of the refrigerant of group II.

The spaces intended for storage of the refrigerant are to be gastight.

In case of storing small amounts of group I refrigerant the departure from the above mentioned requirements is allowed in agreement with *Register*.

3.2.2 The refrigerant storage cylinders are to be secured in place in such a way that they will not shift in adverse weather conditions.

Non-metallic pads are to be placed between the steel plating and the storage cylinders as well as between storage cylinders themselves.

3.2.3 The refrigerant storerooms shall be provided with an independent ventilation system and are to be isolated so as to prevent temperature exceeding +45°C.

3.2.4 Storage cylinders containing compressed gases other than the refrigerant gas are not permitted to be stored in spaces of refrigerant storage. Combustible materials are not to be used for the outfit of these spaces.

3.2.5 Storage of refrigerant in fixed receivers is permitted on condition that the receivers and spaces are arranged in compliance with requirements stated in 3.1.7, 3.1.9, 5.1.1, 5.1.2, 5.1.4, 6.2.5 and 6.2.6. Provision shall be made for sucking off group II refrigerant from the service piping of each receiver after complete filling of the system or periodical replenishing.

Service piping of receivers designed for refrigerant storage is not to pass through accommodation and service spaces.

3.3 REFRIGERATED CARGO SPACES

3.3.1 The envelopes of individual refrigerated cargo spaces are to be sufficiently airtight.

All openings in the boundary walls of refrigerated cargo spaces are to be provided with airtight covers.

3.3.2 Cooling apparatus, grids, mechanisms, devices as well as piping and air ducts arranged in the refrigerated cargo spaces are to be efficiently secured and protected from being damaged by cargo.

3.3.3 Where the air cooling system is used, the air coolers may be located either in separate spaces or in the same spaces as the cargo cooled. Being arranged in the refrigerated cargo spaces, the air coolers are to be provided with condensate tray. For the refrigerated spaces with the ambient temperature being negative the condensate trays are to be provided with the heating system.

The use of air coolers with direct expansion of group II refrigerant is not permitted.

3.3.4 Where the air cooling system is adopted, the air coolers are to be made accessible with the cargo space being entirely loaded with refrigerated cargo. Alternatively, access to the air coolers shall be provided from adjacent non-cooled spaces. The access opening of the air cooler space is to be as large as to permit the fan impeller and electric motor to be carried through, if necessary.

3.3.5 In places where air ducts of the air cooling system pass through watertight bulkheads, sluice valves are to be fitted. These sluice valves are to be designed for the same pressure as the bulkhead. The sluice valves are to be operable from positions above the bulkhead deck which are accessible at any time required.

3.3.6 Appropriate ventilation system capable of supplying uncontaminated atmospheric air (cooled or heated, as necessary) into the spaces of refrigerated cargoes requiring adequate air exchange during carriage shall be provided.

3.3.7 Each air inlet and outlet is to have an arrangement to permit airtight closing.

3.3.8 Air ducts passing through refrigerated cargo and other spaces are to be airtight and efficiently insulated.

3.3.9 Where air cooling of the cargo holds of unclassed refrigerating plants is effected through direct expansion of group II refrigerant in the air coolers, provision is to be made for an independent ventilation system to serve each hold or group of them.

3.3.10 Facilities for heating the refrigerated cargo spaces are to be provided for the carriage of fruit cargoes to maintain the carrying temperatures when the temperatures outside the spaces are lower.

3.3.11 The refrigerated spaces are to be fitted with telethermometric arrangements. In the absence of these arrangements the refrigerated spaces are to be fitted with not less than two thermometric tubes of not less than 50 mm in diameter. The portions of thermometric tubes that pass through non-cooled spaces are to be carefully insulated.

3.3.12 Drainage of refrigerated spaces is to conform to the requirements stated in the *Rules, Part 8-Piping*, 2.7.

3.3.13 Leading of pipes in refrigerated cargo spaces are to comply with requirements stated in the *Rules, Part 8-Piping*, 1.6.4.

3.4 FREEZING AND COOLING CHAMBERS

3.4.1 The arrangement of air coolers and fans in freezing chambers is to comply with requirements of 3.3.1 and 3.3.3.

3.4.2 Spaces containing the refrigerating units are to be equipped with proper devices permitting to check the operation of freezing and cooling apparatus using direct expansion of refrigerant.

3.4.3 If direct expansion group II refrigerant is used in the systems of the freezing chamber, an emergency exhaust ventilation is required and the space of the chamber is to be gastight.

3.4.4 Valves and fittings of the piping carried inside the freezing chamber are to be located in the portion of the piping outside the chamber.

3.5 SPACES CONTAINING PROCESSING EQUIPMENT

3.5.1 The arrangement of machinery, apparatus and refrigerant pressure vessels in spaces other than the refrigerating machinery spaces will require special consideration by *Register* in each case.

3.5.2 Spaces containing the processing equipment in connection with direct expansion of group II refrigerant are to be provided with a fire hydrant and hose of the water fire main system.

3.5.3 Spaces containing the processing equipment are to have independent ventilation. In addition to the ventilation at work in the spaces of processing equipment where direct expansion of refrigerant is used, there should be provided an emergency ventilation system. The number of air changes per hour determined for the main and emergency ventilation systems is to comply with requirements of 3.1.8 and 3.1.9.

3.5.4 In spaces containing the processing equipment using direct expansion of group II and group III refrigerants there shall be two escape ways, as it is specified in 3.1.3 and 3.1.4. When using group II refrigerant, the escape ways are to be fitted with arrangements capable of producing water screens. The cut-in device of the screens shall be placed outside of the space in immediate proximity to the door.

4 MACHINERY

4.1 COMPRESSORS

4.1.1 Compressors are to comply with the requirements specified in this part of the *Rules* and also with those of *Part 9-Machines*, 5.1.3 and 5.1.4.1

4.1.2 Parts of compressors exposed to the action of dynamic loads and excessive pressures are to be calculated for strength having in view design pressures in compliance with 2.2.2.

4.1.3 The refrigerant suction and delivery sides of the compressor are to have stop valves apart from the automatic valves.

4.1.4 Cavities in compressors reserved for refrigerant, lubricating oil and cooling water are to have drain arrangements where necessary.

4.1.5 A pressure relief valve or some other self-operating device is to be fitted in the delivery line of the intermediate and final compression stages of compressor between the delivery cavity and the stop valve, the discharge being led to the suction side of the compressor in case of excessive pressure rise. Discharging capacity of the safety devices is to be not less than the maximum volumetric capacity of the compressor stage protected.

The pressure rise shall not exceed 10 per cent of the lifting pressure, with the valve being open.

No shut-off devices are permitted in the refrigerant gas relief line.

Discharge of refrigerant into the atmosphere is subject to special consideration by *Register* in each case.

4.2 PUMPS

4.2.1 Pumps are to comply with requirements set out in 5.2 of the *Rules, Part 9-Machinery*.

4.3 FANS

4.3.1 Fans are to comply with requirements set out in the *Rules, Part 9-Machines*, 5.3.

5 HEAT EXCHANGERS, PRESSURE VESSELS AND COOLING ARRANGEMENTS

5.1 HEAT EXCHANGERS AND PRESSURE VESSELS

5.1.1 Heat exchangers and pressure vessels regarding materials, scantlings of components and provision with fittings are to comply with relevant requirements of the *Rules*, *Part 10-Boilers, Heat Exchangers and Pressure Vessels*, Chapter 6 (except for 6.3.1, 6.3.3, 6.4.1, 6.4.2.3 and 6.4.2.4) and also with requirements of this part of the *Rules*.

5.1.2 Pressure vessels and heat exchangers for refrigerants of group II. and III. are graded in accordance with *Rules, Part 10-Boilers, heat exchangers and pressure vessels*, item 1.3.1.2, in equipment of class I.

Pressure vessels and heat exchangers for refrigerants of group I. are graded in equipment of class II.

5.1.3 Shell and tube heat exchangers and pressure vessels with the volume of the refrigerant space of 50 dm^3 and over are to be fitted with safety devices having discharging capacity so designed that the pressure will not rise in excess of 10 per cent of the lifting pressure, with the valve being completely open.

The designed discharging capacity G is to be not less than determined by the formula

$$G = \frac{qS}{r} \quad \text{[kg/s]} \qquad (5.1.2)$$

where:

- q – specific intensity of the heat flow from the space during fire, kW/m² (assumed to be 10 kW/m² in all cases),
- S – area of the outer surface of pressure vessel (heat exchanger), m²,
- r – specific heat of the refrigerant vaporisation under opening pressure of the safety valve kJ/kg.

The safety devices shall consist of two safety valves and a change-over device so constructed that both or one of these valves will, in any case, communicate with the heat exchanger or pressure vessel involved. Each of these valves is to provide full discharging capacity.

Instead of safety valves *Register* may permit use of an other adequate safety device.

Register may require that the safety valves are also fitted in other apparatus if this is deemed expedient.

No shut-off valves are permitted between the heat exchanger or pressure vessel and the safety device.

The use of safety devices with one safety valve or safety devices of other types is subject to special consideration by *Register* in each case.

5.1.4 Heat exchangers and pressure vessels are to have suitable facilities for removing water, air, lubricating oil and liquid secondary refrigerant.

5.1.5 Heat exchangers and pressure vessels with group II and group III refrigerants are to have suitable facilities for emergency dumping of the latter.

The rated time of refrigerant dumping shall be not more than two minutes with refrigerant in heat exchangers or pressure vessels under constant excessive pressure assumed equal to the design pressure according to 2.2.2.

5.1.6 Oil separators are to be provided at compressor discharges.

5.1.7 Liquid receivers are to be provided with sufficient capacity to hold the complete refrigerant charge during servicing or repairs. Liquid receiver is to be fitted with shut off valves.

Receivers are to be fitted with flat gauge glasses having self closing valves at each end.

5.2 AIR COOLERS

5.2.1 Where direct expansion of refrigerant is used, the coils of air coolers are to have welded connections. Flanged connections between the coil sections and pipes are permitted only when this is proved necessary; all flanged connections are to be arranged in readily accessible places to enable inspection for tightness.

5.2.2 Where a single air cooler is used, its evaporator is to be arranged in not less than two sections, each of which is to be capable of being disconnected, if necessary.

6 FITTINGS AND PIPING

6.1 FITTINGS AND SAFETY VALVES

6.1.1 The refrigerating plants are to be provided with shut-off, regulating and safety devices, designed for pressure of not less than 1,25 p where p is pressure as given in 2.2.2.

As a rule, steel fitting and valves are to be used. The use of other types of materials is subject to special consideration by *Register*.

The integral shut-off valves and fittings made of laminar graphite cast iron which are intended for the inlet and outlet of the refrigerant compressors, as well as the valves and fittings made of spherical graphite cast iron may be permitted when using group I and group II refrigerants at ambient temperatures of not less than -40°C.

6.1.2 Safety valves are to be opened at a pressure exceeding the design pressure as given in 2.2.2 by not more than 10 per cent.

6.2 PIPING

6.2.1 The piping of refrigerant, liquid refrigerant, secondary refrigerant and cooling water systems are to comply with respective requirements set out in the *Rules, Part 8-Piping*, 1.3 (except for 1.3.6 and for refrigerant piping 1.3.6 and 1.3.7), and is also to meet the requirements of this chapter.

Piping of group II and group III refrigerants and piping of group I liquid refrigerants belong to piping class I in accordance with the *Rules, Part 8-Piping*, Table 1.2.2.

6.2.2 The piping of refrigerant and liquid secondary refrigerant is to be made of seamless pipes. The piping of the liquid secondary refrigerant is to be made of steel pipes. The joining of steel pipes carrying the refrigerant is, as a rule, are to be made by welding and, where copper pipes are concerned, by welding or brazing. Where pipes are joined with valves, mechanisms, heat exchangers and pressure vessels, detachable connections may be admitted.

6.2.3 The refrigerant discharge piping of the compressors and refrigerant pumps is to be fitted with non-return valves. These valves may not be used for compressors working with group I refrigerant and having no discharge facilities.

6.2.4 Refrigerant dryers for moisture absorption are to be fitted on the liquid piping carrying the refrigerant slightly soluble in water. They are to be fitted together with gauze filters in the liquid lines to the regulators or structurally connected with them.

6.2.5 The pipes leading from safety valves (except for those in 4.1.5) are to be led overboard in a place below the waterline corresponding to the minimum draught of the ship. These pipes are to be fitted with refrigerant leak detectors and non return valve fitted directly to the ship's side.

It is permitted to discharge group I refrigerant to the open air at a position safe for persons.

6.2.6 The pipes for refrigerant dumping from heat exchangers and pressure vessels in emergency are to terminate into a collecting pipe located outside the refrigerating machinery space, but near the access thereto. Each dumping pipe is to be fitted with shut-off valves located near the collecting pipe and refrigerant leak detectors placed after each valve. These valves are to be protected from opening by unauthorised persons and must be so constructed as to be blocked when closed. The collecting pipe of the emergency dumping is to have a non-return valve and be led overboard below the waterline of the minimum draught. To permit clearing of the collecting pipe, steam or compressed air connections are to be provided.

The inner diameters of the refrigerant emergency dumping pipes of separate heat exchangers and pressure vessels are to be not less than the diameter of the relief valve determined as required in 5.1.2. The cross-sectional area of the emergency collecting pipe is to be not less than the total cross-sectional area of three largest dumping pipes connecting on it.

6.2.7 For the pipe led overboard in a place below the waterline, according to 6.2.5 and 6.2.6 the minimum wall thickness in all cases is to be not less than specified in the *Rules, Part 8-Piping*, column 3 of Table 1.3.4.3.

6.2.8 Group II refrigerant piping is not to pass through accommodation spaces.

6.2.9 Brine tanks are to have ventilating pipes led to the weather away from ventilation inlets and openings to accommodation spaces. Wire gauze is to be fitted to the ventilating pipe outlets.

7 INDICATING AND MEASURING INSTRUMENTS AND AUTOMATIC DEVICES

7.1 INDICATING AND MEASURING INSTRUMENTS

7.1.1 The compressors and apparatus of the refrigerating plants are to be fitted with suitable devices to permit the working parameters being monitored. Besides, the arrangement should be provided for the possibility of installing additional indicating and measuring instruments required when testing the plant.

7.1.2 Indicating and measuring instruments are to be placed in readily accessible and visible positions. The scales are to be placed in readily accessible and visible positions. The scales are to bear clear marks indicating the minimum and maximum admissible values of the parameters controlled.

Indicating and measuring instruments, except the temperature measuring instruments, are to be checked and accepted by the authorities which are recognised by *Register*.

7.2 AUTOMATIC DEVICES

7.2.1 Automatic systems as well as the elements and components constituting these systems are to comply with requirements stated in the *Rules, Part 13-Automation*.

7.2.2 Where automatic control of the refrigerating plant is used, facilities for manual operation are also to be available. Manual operation may not be provided if two automation devices are fitted.

7.2.3 The refrigerant compressors are to be provided with automatic devices capable of stopping the compressors in case of:

.1 inadmissible drop of suction pressure;
.2 inadmissible rise of discharge pressure;
.3 inadmissible drop of lubricating oil pressure;
.4 inadmissible rise of refrigerant discharge temperature (intended for the refrigerating plants working with group II and group III refrigerants, as well as for automated refrigerating plants with unmanned service);
.5 inadmissible axial rotor displacement of centrifugal compressor;
.6 inadmissible temperature rise in sliding bearings of centrifugal compressors.

7.2.4 Liquid separators, intermediate vessels and liquid refrigerant receivers (where pumps are used for refrigerant circulation), as well as free-level type evaporators are to be fitted with automatic devices capable of:

.1 maintaining constant level of refrigerant liquid necessary for proper work of the evaporator, or maintaining constant temperature of vapour superheating;
.2 stopping the delivery of refrigerant liquid into evaporators and any type of intermediate vessels, in case of compressor shutdown;
.3 stopping the compressor, should the level of refrigerant liquid rise inadmissible.

7.2.5 Plant incorporating shell and tube type evaporators is to be fitted with automatic devices capable of:

.1 stopping the compressor, should the circulation of the refrigerant liquid inside the evaporator be impeded, or when cutting off this evaporator from the refrigerant system;
.2 stopping the compressor, should the temperature of refrigerant liquid drop inadmissible.

7.2.6 The refrigerating plants are to be provided with signal devices (general alarm) which shall give warnings at refrigerating plant control station after interruption of operation of protective automatic devices specified in 7.2.3 to 7.2.5.

Possibility of decoding the above mentioned signals at the local control station shall be provided.

7.2.7 In ships having an automation mark in the class notation, according to the *Rules, Part 1-General requirements*, 2.2.2.3, the automated refrigerating plants are to be provided with:

.1 indicating instrument showing the refrigerating plants are working or not; and
.2 warning signal device indicating deviation of temperature in refrigerating spaces from the temperature required for the cargo carried.

7.2.8 The automated refrigerating plants with unattended operation and the refrigerating plants working with Group III refrigerant are to be provided with gas detecting sensors which actuate alarms at the refrigerating plant control station in case of the refrigerant leak.

7.2.9 The refrigerating plants of ships having an automation mark in the class notation according to the *Rules, Part 1-General requirements*, 2.2.2.3 are to comply with the relevant requirements of the *Rules, Part 13-Automation*, Chapter 4 and 5.

8 INSULATION

8.1 INSULATION OF THE REFRIGERATED SPACES

8.1.1 All metallic work of ship's hull inside the refrigerated cargo spaces is to be efficiently insulated.

8.1.2 The insulating materials adopted for refrigerated cargo spaces are to have adequate resistance to adverse biological factors and are to be of the type that does not give off any odour. The insulating materials are to be approved by *Register*.

8.1.3 Surfaces of the fuel tank bulkheads and the double bottom tank top in way of fuel tanks should be covered with the chocks of oil resisting and inodorous material before putting the insulation.

8.1.4 Care should be taken to prevent the insulation from infiltration with moisture, or, alternatively, suitable means for drying it during service, as well as protective measures against damage by rodents, are to be provided.

8.1.5 The insulation of refrigerated cargo spaces is to be covered with appropriate lining or other protective coating. In places where insulation linings may be crushed by cargo, they are to be suitably protected.

8.1.6 The insulation in freezing chambers is to comply with requirements of 3.3.7, 8.1.2, 8.1.4 and 8.1.5.

8.2 INSULATION OF PIPING

8.2.1 Where pipes are carried through bulkheads and decks, no direct contact with surfaces they pierce is permitted to prevent heat exchange.

8.2.2 Provision is to be made for protecting the insulation of piping from dampness.

8.2.3 Insulation of pipelines shall be of fire resisting materials in accordance with the *Rules, Part 17, Fire Protection*, 2.1.1.8. This requirement does not apply to insulation of pipelines within areas of refrigerated cargo spaces and refrigerated spaces.

8.2.4 Materials which prevent condensation and the glues used with the insulation as well as the insulation of fittings may not comply with the *Rules, Part 17, Fire Protection*, 2.1.1.8, provided that their quantity is minimum and surface of their open parts have low flame spread characteristics.

9 TESTS

9.1 TESTS AT MAKER'S WORKS

9.1.1 Tests of the refrigerating plant components listed in this chapter are to be carried out in the presence of a surveyor of the *Register*.

9.1.2 Hydraulic tests for strength of the components working under the refrigerant pressure are to be carried out at a test pressure of not less than 1,5 p where p is in accordance with 2.2.2, with the exception of reciprocating compressor crankcases which are to be subjected to a test pressure of not less than the design pressure.

Components working under the pressure of liquid secondary refrigerant or water are to be tested at a hydraulic pressure of 1,5 times the working pressure, but not less than 0,4 MPa.

9.1.3 Pneumatic leak tests of the components working under the refrigerant pressure are to be carried out at a test pressure of not less than the design pressure assumed according to 2.2.2 with the exception or reciprocating compressor crankcases for which the test pressure is to be not less than 0,8 times the design pressure.

9.1.4 Fittings in assembly and automatic devices provided with shut-off facilities in addition to the above mentioned tests shall be subjected to a leak test by pneumatic pressure equal to the designed pressure in accordance with 2.2.2.

9.1.5 The machinery and equipment specified in 1.3.2 after assembling are to be tested in accordance with requirements of the *Rules, Part 9-Machines*, 1.4.

9.2 TESTING OF REFRIGERATING PLANTS ON BOARD SHIP

9.2.1 After the refrigerating plant has been completely assembled on board, the entire refrigerant systems is to be subjected to gas leak tests at a working pressure in accordance with 2.2.2.

9.2.2 Tests on board may be carried out with dry air, carbon dioxide or nitrogen.

9.2.3 Upon leak testing the refrigerant system is to be dried. Refrigerant system is to be subjected to the vacuum-tight tests at a residual pressure of not more than 1,0 kPa.

9.2.4 After the system has been filled with refrigerant all joints and fittings are to be checked for leak.

9.2.5 All the pipes of liquid secondary refrigerant and of the cooling water, together with pertaining fittings are to be tested on board ship on tightness in normal operating conditions.

9.2.6 Where air circulating fans and fans for fresh air ventilation of cargo spaces are provided, it is to be ascertained that the velocity of circulating air and the state of air circulation are satisfactory.

9.2.7 Automatic control devices, safety devices and alarms are to be checked that they operate satisfactory.

9.2.8 The refrigerating plant is to be operated to demonstrate its ability to operate with all possible variations in connections that can be made with compressors, condensers and evaporators.

9.2.9 To check the fulfilment of the requirements of 2.3 the refrigerating plant is to be subjected to the refrigerating capacity tests, as follows:

.1 Refrigerated cargo spaces are to be cooled down to the required temperature.
After achieving the required temperature in refrigerated cargo spaces, it is to be maintained constant without any adjustment of the output of the refrigerating plant.

.2 Upon achieving balance condition (temperature in refrigerated space does not vary by more than ±0,5°C in each hour), the necessary measurements are to be taken once an hour for at least six hours in order to calculate the mean coefficients of overall heat transmission.
Records of measurements and calculations are to be submitted to the Register for evaluation.
It is to be ascertained that the heat leakage obtained by this test is not more than the designed value taken in the calculation of the refrigerating capacity (demand).

.3 Outside surfaces of the bulkheads, shell, decks, openings as well as pipe and cable penetrations are to be checked for excessive condensation or frost indicative of voids and thermal bridges in the insulation.

9.2.10 The defrosting arrangements for air coolers are to be tested for satisfactory operation.

10 SPARE PARTS

10.1 GENERAL REQUIREMENTS

10.1.1 Each refrigerating plant is to be provided with spare parts carried on board to an extent that is not less than required in this Chapter.

10.1.2 The spare parts are to be secured in accessible positions marked and protected against corrosion in an effective way.

10.2 MINIMUM REQUIRED SPARE PARTS

10.2.1 Compressors, pumps and internal combustion engines driving the compressors are to be supplied with spare parts according to provisions of the *Rules, Part 7-Machinery Installations*, Chapter 5.

Electric motors of compressors, pumps and fans are to be supplied with spare parts according to provisions of the *Rules, Part 12-Electrical Equipment*, Chapter 4.

10.2.2 Apart from the requirements of 10.2.1, the refrigerating plants are to be supplied with spare parts in accordance with Table 10.2.2.

Table 10.2.2

No.	Item	Quantity
1	Compressor piston with connecting rod complete, of each type used	1
2	Compressor crankshaft seal of each type used	1
3	Liner of compressor cylinder of each size and type used	1
4	Blades of rotary compressor of each size and type used	1 set for 1 compressor
5	Fan impeller with shaft, for refrigerated spaces and freezing chambers of each type used	1
6	Refrigerant expansion valve of each size and type used	1
7	Assorted cocks, valves and fittings of each size and type used	1
8	Gaskets and packings of each size and type used	1
9	Thermometers, pressure gauges and vacuum gauges of each size and type used	1
10	Safety valves springs of each size used	2
11	Leak detector, where freon is refrigerant	1
12	Areometer (only where the brine is used)	1

Note:
1) Rapid wearing parts of seals may be provided for spare parts only if construction allows exchange

11 CONTROLLED ATMOSPHERE SYSTEMS

11.1 GENERAL

11.1.1 The requirements of this Chapter are applicable to systems installed on board, either temporary or permanent, for generating and supplying nitrogen enriched gases to the refrigerated cargo spaces and for controlling the atmosphere in those spaces. Generation and supply of other non-toxic gases for this purpose will be subject to special consideration.

11.1.2 Portable Nitrogen generating equipment intended to serve multiple ships is to comply with all the relevant requirements of this Chapter and is to be approved in consideration with the specific ships it is intended to serve.

11.1.3 The Nitrogen generating equipment is to be designed, manufactured and installed in accordance with good commercial practice and is to be suitable for intended service conditions including the marine environment.

11.1.4 The following plans and data are to be submitted for approval:

- Capacity calculation for the Nitrogen plant
- Arrangements for controlling the CO_2 in cargo hold
- Details of CO_2 and Ethylene scrubber
- Details of compressors and prime movers
- Details of the pressure vessels and heat exchangers
- General arrangement of Nitrogen generation plant, indicating location and access
- Ventilation details of Nitrogen generator space
- Piping system, arrangement and details
- Arrangements to render cargo spaces gas tight; to include details of liquid sealed traps
- Arrangements for pressure and vacuum relief in cargo spaces
- Ventilation arrangements, for designated controlled atmosphere spaces, and adjacent spaces
- Schematic diagram of control and monitoring systems
- One line electrical wiring diagram and details of the power supply
- Details of the gas analysing system
- A list of alarms and displays
- Details of the humidification system
- Details of personnel safety equipment
- Operations, equipment and procedure manual

Table 11.1
Instrumentation and Alarms

Item		Display	Alarm	Remarks
Compressor	Automatic stop		Activated	
	Lubricating oil	Pressure	Low	Automatic stop (Low pressure)
	Discharge line - Pressure	Pressure	High	Automatic stop (High pressure)
	Suction line - Pressure	Pressure	Low	
O_2 Content	Spaces under controlled atmosphere	Content	Deviation from set point	
	Accessible spaces/cargo spaces adjacent to spaces under C.A.	Content	Low	
	Gas generating compartments	Content	Low	
	Gas generating container	Content	Low	
	Cargo spaces with containers under controlled atmosphere	Content	Low	
	Accessible spaces containing scrubber units and gas piping	Content	Low	
CO_2 Content	Space under controlled atmosphere	Content	Deviation from set point	
Gas Measuring System	Failure		Failure	
	Accuracy		Out of range	
Humidification System	Relative humidity	Relative humidity	Deviation from set point	If humidification system is fitted
Gas Supply main	Pressure	Pressure	Deviation from set point	
	Temperature	Temperature		
	Content			
	Flow			

11.2 DESIGN CONSIDERATIONS

11.2.1 The controlled atmosphere plant is to be able to achieve and maintain the O_2 levels in the designated spaces within a range between 2% and 10% by volume. However, O_2 levels outside this range will be considered depending on the cargoes carried.

11.2.2 The controlled atmosphere plant is also to include equipment for controlling the CO_2 levels in the designated spaces within the pre-requisite ranges.

CO_2 levels may be controlled by means of nitrogen purge.

11.2.3 Capacity

.1 Volumetric capacity of the Nitrogen plant is to be such that the Oxygen content in the refrigerated cargo hold spaces can be reduced to value below 5% within 24 hours, in accordance with the following equation:

$$Q = 0{,}07\ V$$

where:

Q [m^3/h] – Nitrogen generating capacity, delivering 3% oxygen, at standard atmospheric conditions; and,

V [m^3] – General cargo carriers: internal volume of all empty cargo spaces simultaneously under controlled atmospheres, exclusive of insulation.

– Container carriers: Total empty internal volume of all containers simultaneously under controlled atmosphere.

– Combined general cargo and container carriers: Sum of volumes calculated as above.

.2 The required capacity of controlled atmospheres may vary due to variations in types of cargoes, sealing arrangements and other relevant parameters and therefore is to be specified by the designer/Owner. The specified capacity of the system is to be indicated on the submitted plans.

11.2.4 The Nitrogen generating equipment is to be capable of delivering its rated capacity against a back pressure at the cargo space inlet equal to the pressure setting of the PV valve which is protecting that space.

11.3 NITROGEN GENERATOR

11.3.1 Compressor

.1 Nitrogen generating systems utilising compressors are to be provided with two or more compressors and prime movers which together will be capable of delivering the rated capacity. Each compressor is to be seized so that with one compressor out of operation, the system is to be able to maintain the O_2 content in all designated cargo spaces within the range specified in 11.2.1 above.

.2 Alternatively, one compressor and prime mover may be accepted if the compressor is capable of delivering the specified capacity and provided that spares for the compressor and prime mover are carried to enable any failure of the compressor and prime mover to be rectified on board.

11.3.2 Gas Separator

Where membrane gas separators are used, the system is to be arranged such that 20% of the total capacity required in accordance with 11.2.3 is maintained in reserve. Arrangements utilising other types of gas generating processes are to be not less effective.

11.4 LOCATION AND ACCESS FOR COMPARTMENTS CONTAINING GAS GENERATING EQUIPMENT

11.4.1 The gas generating equipment is to be located in a separate gas generator compartment or in a container located on the open deck.

11.4.2 Where the gas generating equipment is located in a dedicated gas generator compartment, the following requirements are to be met:

.1 Equipment for generation, storage, distribution and regulation of controlled atmosphere gases only are to be located in such space.

.2 Access to this space is to be provided only from the open deck.

.3 The space is to be separated by gastight steel bulkheads and decks from the adjacent spaces.

.4 All penetrations of the space boundaries are to be made gas tight.

.5 The space is to be provided with an independent mechanical ventilation system of the exhaust type giving at least 20 air changes per hour based on total volume of the space.

.6 Ventilation ducts from this space are not to pass through accommodation spaces, service spaces, machinery spaces or control stations.

.7 All ventilation outlets from spaces under controlled atmosphere are to be located at least 2 m above the open deck and 5 m away from air inlets and openings to accommodation spaces, service spaces, machinery spaces and other similar manned spaces.

.8 Means for stopping ventilation fans and closing all the openings to the gas genera-

tor compartment are to be provided from outside of the space.

.9 This space is to be designated as a dangerous area and notices are to be posted to that effect.

.10 Means are to be provided for stopping the gas generator from outside of the space.

11.4.3 Where the gas generating equipment is located in a container positioned on the open deck, the following requirements are to be met:

.1 The container is to be provided with a mechanical ventilation system of the exhaust type giving at least 20 air changes per hour based on total volume of the container.

.2 The outlets of the ventilation exhaust ducts from the container are to be located such that the exhaust cannot enter enclosed spaces on the vessel.

.3 Means for stopping the ventilation fans and closing all the openings to the gas generator container are to be from outside.

.4 Unrestricted access to the container is to be possible under all loading conditions.

.5 Two portable fire extinguishers complying with *Rules, Part 17-Fire protection*, item 5.1.2 are to be provided inside the container, of which one is to be stowed near the entrance to the container. Where the compressors are driven by internal combustion engines and the fuel tanks are located inside the container, an approved fixed fire extinguishing system complying with *Rules, Part 17-Fire protection*, item 3.1.2 may be required, depending upon the arrangement.

.6 The container is to be designated as a dangerous area and notices are to be posted to that effect.

.7 Means are to be provided for stopping the gas generator from outside of the container.

.8 The container is to be properly secured to the vessel. The container is to be designed considering proper support for the equipment and is to be suitable for the marine environment.

11.5 GAS AND COMPRESSED AIR PIPING SYSTEM

11.5.1 Installation

.1 Where flexible hoses on deck are intended to be used for the supply of Nitrogen gas to the refrigerated cargo spaces, they are to be of an approved type complying with the requirements of *Rules, Part 8-Piping*, item 1.3.18. Means are to be provided for protecting these hoses against damage.

.2 Permanently installed piping system for the supply and distribution of Nitrogen (N_2) gas is to be in compliance with *Rules, Part 8-Piping*.

A positive closing isolation valve is to be fitted in the gas supply line at the inlet to the refrigerated cargo space. This valve arrangement is to be in accordance with 11.5.2.1 or 11.5.2.2 of this Chapter.

.3 Exhaust of O_2 and N_2 enriched gases from Nitrogen generators are to be led to a safe location in the weather, at least 2m above the open deck and 5m away from ventilation inlets and openings to enclosed spaces.

.4 Gas pipes are not to pass through accommodation spaces, ducts or tunnels.

.5 Gas pipes passing through service, machinery and control spaces are to be led through gas tight pipes.

11.5.2 Valve and Fittings

.1 Each gas inlet line to an individual controlled atmosphere space is to be equipped with two shut-off valves and an intermediate vent valve. Discharge from the vent valve is to be led to a safe location in the weather, away from ventilation inlets and openings to enclosed spaces. The shut-off valves are to be provided with arrangements for locking in the closed position.

.2 If a portable Nitrogen generating plant is used, the arrangement in 11.5.2.1 may be dispensed with if it is not possible to supply Nitrogen to more than one space at a time. In this case, each permanent gas inlet line is to be equipped with a screw down non return valve provided with arrangements for locking it in the closed position.

.3 Filters are to be provided in the air supply to membrane separators to ensure filtration of oil, debris and water particulate.

11.6 SAFETY RELIEF DEVICES

11.6.1 Safety relief devices are to be provided in each section of pipe that may be isolated by valves and may build up a pressure in excess of the design pressure. Discharges from relief valves on gas lines are to be led to the weather, at least 2m above the open deck and 5m away from ventilation inlets and openings to enclosed spaces.

11.6.2 Each air compressor for the nitrogen generating plant is to be provided with a relief valve on the discharge side.

11.6.3 Pressure vessels with isolating valves are to be equipped with a pressure relief valve set to relieve at a pressure not greater than the design pressure.

11.7 CARGO SPACES UNDER CONTROLLED ATMOSPHERE AND ADJACENT SPACES

11.7.1 General

.1 Where the tween-deck spaces within cargo holds are fitted with separate means of maintaining controlled atmosphere conditions, each tween-deck space is to be considered an independent gas tight compartment. For container carriers where the containers stowed under deck are supplied with a low oxygen atmosphere, each container is to be considered a gas tight compartment.

.2 Each cargo space under controlled atmosphere conditions is to be made gas tight as far as practicable. The arrangements are to be such as to ensure that when cargo space is pressurised with an over pressure of 20 mm of water column, the time taken for a 40% pressure drop is greater than 16 minutes.

.3 Openings for all pipes, ducts, cables, sensors, sampling lines and other fittings passing through the decks and bulkheads are to be suitably sealed and made airtight.

.4 Hatch covers and doors to spaces under controlled atmosphere are to be provided with locking arrangements and warning notices informing about the low oxygen atmosphere.

.5 Warning notices are to be posted at all openings to spaces under controlled atmosphere to prevent inadvertent opening while the space is under the controlled atmosphere.

11.7.2 Pressure and Vacuum Considerations

.1 Each cargo space or compartment under controlled atmosphere is to be provided with a pressure and vacuum relief valve (PV valve) to limit the positive and negative pressure below that for which the space is designed.

.2 The pressure relieving capacity of the PV valve is to be such as to ensure that the pressure in the space does not exceed the design limits referred to in 11.7.2.1 above, when the gas generating unit is delivering at its maximum capacity to a single cargo space or compartment.

.3 Outlets of PV valves are to be located at least 2m above the open deck and 5m away from air inlets and openings to accommodation spaces, service spaces, machinery spaces and other similar manned spaces.

.4 The PV valves are to be of a type suitable to satisfy the requirements of 11.7.2.1.

.5 Arrangements for the protection of cargo spaces or compartments against over or under pressure other than those referred to above will be the subject of special consideration.

11.7.3 Bilge and Drainage Arrangements

.1 Liquid sealed traps on drains from cargo spaces, air cooler trays, etc. are to have sufficient liquid head to withstand the design over pressure when the Controlled Atmosphere system is in operation. Ship motions and over pressure of air circulation fans are to be considered when determining the required liquid head.

.2 The liquid in the liquid seal traps is to be of a type that will not freeze or evaporate under any ambient condition.

.3 Spaces under controlled atmosphere are not to have bilge wells or drain tanks common with spaces not intended for controlled atmosphere.

.4 Where it is intended to gain access to the tween-deck spaces referred to in 11.7.1.1, any open ended interconnecting pipe work between such spaces is to be arranged to prevent Nitrogen gas from escaping from one gas tight space to another.

11.7.4 Ventilation

.1 The ventilation inlets and outlets of cargo spaces under controlled atmosphere are to be provided with positive closing gas tight valves.

.2 All ventilation outlets from spaces under controlled atmosphere are to be located at least 2 m above the open deck and 5m away from air inlets and openings to accommodation spaces, service spaces, machinery spaces and other similar manned spaces.

.3 Suitable arrangements for gas freeing the spaces under controlled atmosphere conditions are to be provided. Air circulation and ventilation fans may be used for this operation. The ventilation outlets used for gas freeing are to be directed vertically upwards.

.4 Compartments other than tanks, void spaces or other similar areas where personnel do not normally have access, which are adjacent to refrigerated cargo spaces under controlled atmosphere, and other normally accessible spaces containing gas piping where gas leakage may create an oxygen deficient atmosphere, are to be provided with permanent mechanical ventilation systems of the positive pressure type with a capacity of at least 2 air

changes per hour based on total volume of the space. The ventilation is to be able to be controlled from outside of the space.
The permanent ventilation outlets are to be located in accordance with 11.7.4.2 above.

.5 Cargo spaces with containers under controlled atmosphere which have arrangements to vent low oxygen air from each container under controlled atmosphere into the cargo space, and which are required to be entered by personnel, are to be provided with ventilation arrangements which are capable of maintaining a minimum of 19,5% oxygen by volume throughout the space.
The ventilation is to be able to be controlled from outside of the space. Ventilation outlets are to be in accordance with 11.4.2.7.

11.8 INSTRUMENTATION,CONTROL AND MONITORING

11.8.1 General

.1 Within the specified ranges, the levels of O_2 and CO_2 are to be able to be maintained with an accuracy within 0.2%.

.2 A permanently installed monitoring system is to be arranged to display the O_2 and CO_2 content in all spaces under controlled atmosphere. The equipment for measuring CO_2 content is to be suitably positioned in the cargo spaces and is to be located away from the fresh air ducts.

.3 Injection of nitrogen and removal of CO_2 and ethylene may be arranged either manually or automatically.

.4 Instrumentation is to be fitted for indicating continuously the gas pressure and temperature in the supply main.

11.8.2 Sampling

.1 The permanently installed monitoring system is to be provided with independent sampling lines or gas sensors for each cargo space under controlled atmosphere.

.2 Where the sampling lines are connected to a monitoring unit which is located in an enclosed space, that space is to be ventilated at a rate which is at least equivalent to the sampling flow rate.

.3 The exhaust gases from measuring and analysis devices are to be discharged to a safe location on the open deck. The exhaust outlets are to be positioned in accordance with 11.7.4.2.

.4 Sampling line arrangements are to be such as to prevent condensation and freezing of water in the lines under all operating conditions. Inlets of sampling lines are to be provided with filters to prevent dirt and debris entering the lines.

.5 In addition to the sampling line or gas sensor required in 11.8.2.1, another closeable sampling line is to be provided for each cargo space under controlled atmosphere. This line is to be arranged for attachment of portable O_2 and CO_2 measuring devices as close as possible to the space served.

.6 Portable equipment for measuring O_2 and CO_2 is to be available on board at all times.

11.8.3 Analysing

.1 If an automatic control system is installed, a gas analysing equipment independent from the one used by the monitoring system is required. However, common gas sampling lines may be used.

.2 Where a gas monitoring system with sequential analysing is arranged, the system is to be designed so that each measuring point is analysed at hourly intervals or other suitable duration specified by the Owner/builder. The instruments are to clearly indicate the space being analysed. Direct readout of the gas quantity in any space under controlled atmosphere is to be available on demand.

.3 Gas analysing equipment is to be self calibrating. The accuracy of the O_2 analysers is to be within ±0,1 % by volume. The accuracy of the CO_2 analysers is to be within ±0,25% by volume.

11.8.4 Precaution for Low Level of O_2

.1 The following spaces are to be provided with permanently installed equipment for monitoring O_2 content and be capable of alarming when the O_2 level is low:
- All normally accessible spaces adjacent to spaces under controlled atmosphere.
- Cargo spaces not under controlled atmosphere adjacent to spaces under controlled atmosphere and spaces where gas leakage may create an oxygen deficient atmosphere, e.g. spaces, tunnels or ducts containing scrubber units or gas piping.
- Ship compartments or containers housing gas generating equipment.
- Cargo spaces with containers under controlled atmosphere.

.2 An automatic pre-discharge warning alarm is to be fitted in each space under controlled atmosphere. The alarm is to be arranged to give audible signals continuously for 60 seconds before the gas discharge into that space commences. The alarm may be connected with the O_2 ana-

lyser in a manner that it does not sound if the oxygen level in the space is below 14% by volume.

11.8.5 Monitoring and Alarm

.1 The conditions as per Table 11.1 are to be individually alarmed at the control and monitoring stations.

11.9 ETHYLENE AND CARBON DIOXIDE SCRUBBER

11.9.1 Mechanical scrubbers are to be installed in gas piping system to cargo spaces.

11.9.2 Exhausts from the scrubbers are to be led to a safe location in the weather, in accordance with 11.5.1.3.

11.10 HUMIDIFICATION EQUIPMENT

11.10.1 Where the cargo space under controlled atmosphere is equipped with a humidification system to control relative humidity of the space, the humidification system is to be in accordance with the following requirements:

.1 For general guidance, the humidification system is to be capable of increasing the relative humidity in each of the intended cargo spaces up to a level of 90% at the specified space temperatures and maintain the selected level constant within ±5%.

.2 The humidification system lines in the refrigerated cargo spaces are to be installed to facilitate ease of drainage and are to be provided with suitable heating arrangements, as applicable.

.3 Permanently installed equipment for monitoring relative humidity in the cargo spaces is to be provided.

.4 The deviation of relative humidity from the predetermined set point in each cargo space is to be individually alarmed at the monitoring station.

11.11 PERSONNEL SAFETY EQUIPMENT

11.11.1 Means are to be provided to re-oxygenate the cargo spaces and compartments prior to gaining entry into the spaces which were under controlled atmosphere conditions. Until the O_2 levels which are considered safe for entry have been achieved, entry into such spaces is to be prevented.

11.11.2 At least ten portable oxygen monitors with alarms are to be provided on board.

11.11.3 At least one portable gas analyser capable of measuring O_2 levels in the atmosphere, is to be provided on board for use prior to entry into the spaces under controlled atmosphere. This portable gas analyser is in addition to the equipment required in 11.8.2.6.

11.11.4 A means of two way communication is to be provided between the cargo spaces under controlled atmosphere and the nitrogen release control station. If portable radiotelephone apparatus are adopted to comply with this requirement, at least three sets are to be provided on board. This equipment is in addition to the equipment required by SOLAS Ch III, Regulation 6.

11.11.5 One set of oxygen resuscitation equipment is to be provided on board.

11.11.6 Two self contained breathing apparatus equipped with built in radio communication and lifeline with a belt are to be provided on board together with fully charged spare air bottles with a total free air capacity of 3600 litres for each breathing apparatus. This equipment is in addition to the equipment required by SOLAS Ch II-2, Regulation 17.

11.12 OPERATIONS,EQUIPMENT AND PROCEDURES MANUAL

11.12.1 An Operations, Equipment and Procedures Manual is to be available onboard.

The manual is to provide the following information:

.1 General information about controlled atmospheres including explanation such as what is controlled atmosphere, need for controlled atmosphere, method of controlling atmosphere composition, danger associated with oxygen depleted atmosphere, insidious leakage of gas, etc.

.2 Complete description of the ship's controlled atmosphere installation and diagrammatic arrangements showing the details of the gas tight compartments.

.3 Procedures for gas freeing of Controlled Atmosphere (CA) spaces, methods of ascertaining adequacy of oxygen prior to entry, methods of communication in CA spaces.

.4 Procedures for entering the CA spaces after gas freeing.

.5 Procedures for loading adjacent cargo spaces.

.6 Procedures prior to starting controlled atmosphere equipment.

.7 Procedures for opening shut-off valves on Nitrogen distribution branch lines and attachment of Nitrogen distribution hoses, where applicable.

.8 Procedures for functional testing portable gas generating unit each time it is placed on board.

.9 Procedures during the voyage with controlled atmosphere.

.10 Equipment maintenance procedures and list of spare parts.

.11 Operation, maintenance and calibration instructions for all types of gas detecting, analysing and alarming equipment onboard associated with controlled atmosphere system.

.12 Emergency procedures related to erroneous instrumentation.
.13 Emergency procedures related to personnel overcome by oxygen deficiency.
.14 Emergency procedures related to entry using breathing apparatus.
.15 Instructions for atmosphere testing and gas freeing of spaces without permanent ventilation.

11.13 TESTS AND INSPECTIONS

11.13.1 After completion, functional and capacity testing of the Nitrogen generator is to be carried out in accordance with an approved program at the manufacturer's plant in the presence of the Surveyor. The functional tests should include testing of alarms, shut downs and pressure relief devices. Capacity and quality of the Nitrogen produced may alternatively be verified on board, in the presence of the Surveyor.

11.13.2 The gas piping system is to be leak tested and hydrostatically tested to 1,5 times the maximum working pressure in the presence of the Surveyor.

11.13.3 Air leakage test for cargo spaces are to be witnessed by the attending Surveyor.

11.13.4 Sample lines are to be tested for leakage and blockage in the presence of the attending Surveyor.

11.13.5 The setting of the PV valves is to be verified by the attending Surveyor.

11.13.6 The accuracy of the levels of O_2 and CO_2 in all spaces under controlled atmosphere is to be verified by the attending Surveyor in accordance with 11.8.1.1.

11.13.7 Accuracy of the O_2 analysers and CO_2 analysers is to be verified by the attending Surveyor in accordance with 11.8.3.3.

11.13.8 Low level alarm of O_2 and automatic Nitrogen pre-discharge warning alarm are to be demonstrated in accordance with 11.8.4.

11.13.9 The required alarms and displays are to be verified for satisfactory operation at the predefined set points.