ClassIBS

ISTHMUS BUREAU OF SHIPPING

PART 9
REFRIGERATING INSTALLATIONS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 9 REFRIGERATING INSTALLATIONS

CONTENT

Index of Tables

PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 9 REFRIGERATING INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1. The Rules for Cargo Refrigerating Installations apply to the survey and construction of cargo refrigerating installations and subsidiary installations including controlled atmosphere systems (hereinafter referred to as refrigerating installations) of ships classed or to be classed with the Society intended to be classified under **Part 1A** of the Rules.

2. For the refrigerating machinery within the refrigerating installations specified in **-1** above, the requirements in the Rules apply to the refrigerating machinery using the primary refrigerants listed below. The surveys and constructions of the refrigerating machinery using primary refrigerants other than those listed below are to be as deemed appropriate by the Society.

R 22 : *CHClF*2

R 134 *a* : *CH*2*FCF*3

R 404 *A* : *R*125/*R*143*a*/*R*134*a* (44/52/4 *wt*%) *CHF*2*CF*3 / *CH*3*CF*3 / *CH*2*FCF*3

R 407 *C* : *R*32/*R*125/*R*134*a* (23/25/52 *wt*%) *CH*2*F*2 / *CHF*2*CF*3 / *CH*2*FCF*3

R 410 *A* : *R*32/*R*125 (50/50 *wt*%) *CH*2*F*2 / *CHF*2*CF*3

R 507 *A* : *R*125/*R*143*a* (50/50 *wt*%) *CHF*2*CF*3 / *CH*3*CF*3

R 717 : *NH*3

3. For refrigerating installations of ships with restricted area of service or those of small capacity, some of the requirements in the Rules may be modified appropriately provided that the Society considered it acceptable.

4. The survey and construction of controlled atmosphere systems specified in above **-1** will be considered appropriate by the Society.

5. The relevant requirements in the Rules apply to the materials, equipment, installation and workmanship of the systems, unless otherwise specified in the Rules.

1.1.2 Special Installations

The surveys and construction of refrigerating installations to which the requirements in this part cannot be directly applied for a special reason are to be deemed appropriate at the discretion of the Society.

1.1.3 Equivalency

Refrigerating installations, which do not comply with requirements of the Rules may be accepted, provided that they are deemed by the Society to be equivalent to those specified in the Rules.

1.2 Definitions

The definitions of terms which appear in the Rules are to be as specified in the following **(1)** to **(7)**, unless otherwise specified elsewhere.

(1) Refrigerating installations means refrigerating machinery, insulation for refrigerated chambers, other related appliances in refrigerated chambers, and controlled atmosphere systems to be registered

(2) Refrigerating machinery means a set of refrigerating units which compose refrigerating cycle, consisting of compressors, condensers, receivers, evaporators, coolers, piping and fittings, driving motors for the compressors and refrigerant pumps, automatic controllers, and electrical equipments.

(3) Refrigerating units means in general such machinery as compressors, motors, condensers, evaporators, pumps, etc., necessary to operate refrigerating cycles among the refrigerating machinery.

(4) Brine is a general term for the secondary refrigerants which is cooled by the primary refrigerant and which is a thermal medium to cool the cargo.

(5) Design pressures means the maximum pressure designed by the manufacturer. However, design pressures are not to be less than the values specified in **Table 1.1** depending on the kind of the refrigerants.

(6) Controlled atmosphere systems means such systems as to control and maintain the oxygen content at a low level in the cargo holds by introducing Nitrogen gas therein in order to extend the life of cargoes as subsidiary installations for cargo refrigerating installations

(7) Anniversary Date is the day corresponding to the expiry date of the Classification Certificate, excluding expiry date of the Classification Certificate.

Table 1.1 The Lowest Design Pressure

Refrigerant	High Pressure side (*MPa*)	Low Pressure side (*MPa*)
*R*22	1.9	1.5
*R*134a	1.4	1.1
*R*404*A*	2.5	2.0
*R*407*C*	2.4	1.9
*R*410*A*	3.3	2.6
*R*507*A*	2.5	2.0
*R*717	2.3	1.8

Notes:

1 High Pressure side: The pressure part from the compressor delivery side to the expansion valve.

2 Low Pressure side: The pressure part from the expansion valve to the compressor suction valve. In case

Where a multistage compression system is adopted, the pressure part from the lower-stage delivery side to the higher-stage suction side is to be included.

Chapter 2 REFRIGERATING MACHINE

2.1 General

2.1.1 General Requirements

1. Refrigerating machinery are to be designed taking into account their purpose and service conditions.

2. All components of the refrigerating machinery are to be so constructed and arranged that they can be easily maintained and readily opened up for repair or renewal.

3. Where *R*717 is used as refrigerant, the refrigerating machinery are to comply with the requirements in this chapter and, in addition, they are to comply with the requirements in **Chapter 4**.

4. Primary refrigerant pipes for *R*22, *R*134*a*, *R*404*A*, *R*407*C*, *R*410*A* or *R*507*A* are to be classified into Group III specified in **12.1.3, Part 7**.

5. Pressure vessels for the refrigerant of *R*22, *R*134*a*, *R*404*A*, *R*407*C*, *R*410*A* or *R*507*A* are to be classified in accordance with the requirements in **10.1.3, Part 7**, according to the design pressure specified in **1.2(5).**

6. Refrigerating machinery are to be provided with the following equipment.

(1) Standard thermometer:
2 sets

(2) Hydrometer:
1 set (in the case of brine-cooling)

(3) Refrigerant leakage detector:
1 set

2.1.2 Capacity and Number of Refrigerating Machinery

1. At least two refrigerating units (in general consisting of one refrigerating compressor and its driving motor, one condenser, one evaporator, one pump and other accessories necessary to operate the unit independently) are to be provided and so arranged as to be readily interchanged with each other.

2. The refrigerating capacity of the installation is to be sufficient to maintain the temperatures of the refrigerated chambers specified in the descriptive note added the classification character with of any one unit suspended.

2.1.3 Materials and Welding

1. Materials used for the refrigerating machinery are to be suitable for the refrigerant used, the design pressure, the minimum working temperature, etc.

2. Materials used for the primary refrigerant pipes, valves and their fittings are to comply with the requirements in**12.1.4** to **12.1.6, Part 7** according to the classes of pipes specified in **2.1.1-4** and **3.2.1-1**.

3. Materials used for the pressure vessels exposed to the refrigerant pressure (condensers, receivers and other pressure vessels) are to comply with the requirements in **10.2, Part 7** according to the classes of pressure vessels specified in **2.1.1-5** and **3.2.1-1**

4. Materials listed below are not to be used:

(1) For parts exposed to fluorine-substituted hydrocarbons:

Aluminium alloys containing more than 2% of magnesium

(2) For parts always exposed to water:

Aluminium of which purity is less than 99.7% (except corrosion protection treated materials)

5. The use of cast-iron valves is to be in accordance with the requirements in **Table 2.1**. Even when the use of cast-iron valves are allowed in that Table, such valves are not to be used where the design temperature is lower than 0°C or higher than 220°C. In this case, such valves may be used at temperatures down to -50°C, even if the design temperature is lower than 0°C, provided that they are used under a pressure up to 1/2.5 of the design pressure.

6. Refrigerating machinery using specific materials such as rubber hoses, plastic tubes, vinyl pipes, etc., or aluminium alloys is to be approved or accepted by the Society, considering the refrigerant used or service conditions.

7. The welding for refrigerating machinery are to comply with the relevant requirements in **Chapter 11, Part 7**.

Table 2.1 Service Limitation of Valves made of Iron Casting

Kind of valves	Materials	Application
Stop valves	Gray iron castings with specified tensile strength not exceeding 200 N/mm^2 or equivalent thereto	Not to be used
	Gray iron castings other than those specified in above, Spheroidal graphite iron castings, Malleable iron castings or equivalent thereto	(1) May be used for design pressure not exceeding 1.6 *MPa* (2) May be used for design pressure exceeding 1.6 *MPa* but not exceeding 2.6 *MPa*, provided nominal diameter does not exceed 100 *mm* and design temperature is 150°C or below.
Relief valves	Any iron casting	Not to be used
Automatic control valves	Gray iron castings with specified tensile strength not exceeding 200 N/mm^2 or equivalent thereto	Not to be used
	Gray iron castings other than those specified in above or equivalent thereto	(1) May be used for design pressure not exceeding 1.6 *MPa* (2) May be used for design pressure exceeding 1.6 *MPa* but not exceeding 2.6 *MPa*, provided nominal diameter does not exceed 100 *mm* and design temperature is 150°C or below.
	Spheroidal graphite iron castings, Malleable iron castings or equivalent thereto	Not to be used for design pressure exceeding 3.2 *MPa*

2.2 Construction etc. of Refrigerating Machinery

2.2.1 Refrigerant Compressors

1. Compressor components subject to the refrigerant pressure (including crankcases in the case of reciprocating compressors) are to be so designed to withstand the design pressure for HP side. However, when a relief valve is fitted to the crankcase integral with compressor cylinder, the components mentioned above may be designed for the design pressure for the relief valve.

2. Where the compressor is lubricated by pressure oil, the compressor is to be stopped automatically when the oil pressure falls below a preset value.

3. The compressor is to be provided with an alarm or automatic cut off device which operates where condenser cooling water pressure falls below a predetermined value.

2.2.2 Driving Machines and Gearing

Prime movers and step-up gearing for compressors are to be in accordance with the relevant requirements in **Part 7** and **Part 8** of the Rules**.**

2.2.3 Pressure Vessels Exposed to the Refrigerant Pressure

Design, construction and strength of pressure vessels exposed to the refrigerant pressure (condensers, receivers, and other pressure vessels) are to be in accordance with the requirements in **10.3** to **10.8, Part 7** of the Rules **(**excluding those in **10.8.3**).

2.2.4 Oil Separators

Suitable oil separators with drainage are to be provided to the discharge side of the compressor, except when a unit integrated with evaporator is provided to ensure oil recovery.

2.2.5 Filters

Suitable filters are to be provided in the refrigerant gas lines to the compressors and in the liquid lines to the automatic regulators. Filters may be omitted provided oil separators fitted have filtrating capability.

2.2.6 Refrigerating Driers

Driers are to be provided to the refrigerant pipes for *R*22, *R*134*a*, *R*404*A*, *R*407*C*, *R*410*A* or *R*507*A*. Driers are to be so arranged that they can be by-passed or changed over to a stand-by unit without interrupting the operation of the plant in case of failure. However, such arrangement is not required when the change over to the stand-by unit is ensured by a unit integrated with the evaporator.

2.2.7 Refrigerant Pumps

Where the primary and/or secondary refrigerants are circulated round the system by pumps, a stand-by pump(s) so arranged as to be easily interchangeable with pumps for normal operation is to be provided. Its capacity is not to be less than that of the largest pump for normal operation.

2.2.8 Condenser Cooling Water Pumps

1. At least two separate condenser cooling water pumps are to be provided and so arranged as to be interchangeable with each other. In this case, one of the pumps may be used for other purposes, provided that it is of adequate capacity and its use on other services does not interfere with the supply of cooling water to the condenser

2. Condenser cooling water is to be taken from at least two sea connections (suctions). One of the sea connections is to be provided on the port side and the other on the starboard side.

2.2.9 Piping Systems

1. Design, construction, strength, fabrication and outfitting of piping systems are to be in accordance with the requirements in **12.2** to **12.4**, and **13.2** (excluding those in **13.2.1-6**), **Part 7.**

2. Pipes and pipe flange couplings are to be in accordance with the requirements for air in **Table 12.10**, **Chapter12**, **Part 7.**

2.2.10 Safety Devices against Excessive Pressure

1. A high pressure cut out switch and a relief valve are to be fitted between each compressor (except turbo compressors) and its delivery stop valve. The discharge from the relief valve is to be led to the open air or the low pressure side of the refrigerant system.

2. The refrigerant side of the condenser, the receiver, and parts containing liquid refrigerant, which may be isolated and exposed to a pressure exceeding their design pressure, are to be provided with relief valves or other suitable pressure relieving devices.

3. Pressure vessels used for low pressure side containing liquid refrigerants (including brine coolers and closed type brine tanks) and isolated by stop valves are to be provided with pressure relief valves or other suitable pressure relieving devices.

4. All pumps and piping systems which may be exposed to a pressure exceeding their design pressure are to be provided with relief valves or other suitable pressure relieving devices.

Where discharge from the relief valve on the high pressure side of the primary refrigerant is led to the low pressure side, the arrangement is to be made so that the operation of the relief valve is not affected by back pressure accumulation.

6. Where discharge from relief valves or other pressure relieving devices are led to the open air, the openings are to be located at safe places above the weather deck.

7. Pressure relieving devices are to be capable of preventing the pressure accumulation exceeding 1.1 times the design pressure of the parts to which the devices are fitted.

2.2.11 Automatic Control

Automatic control is to be in accordance with the requirements in **18.2**, **Part 7**.

2.2.12 Electrical Equipment

1. The electric power supply to the refrigerating installation is to be fed by at least two sets of generating units.

2. The capacity of the generating units mentioned above is to be such that in the event of any one generating unit being stopped the remaining generating units are capable of maintaining the temperature of the refrigerated chambers specified in the descriptive note added to the classification character.

3. The construction of electrical equipment arranged in the refrigerating installation is to comply with the requirements in **Chapter 1** and **2**, **Part 8**.

2.3 Cooling Appliances in Refrigerated Chambers

2.3.1 Cooling Grids

Brine cooling grids or direct expansion cooling grids in each refrigerated chamber are to be divided in at least two sections so arranged that each section can be shut off, where necessary.

2.3.2 Air Cooler

Cooling coils of each air cooler are to be arranged in not less than two sections, each of which can be shut off where necessary. Alternatively, at least two independent air coolers are to be provided.

2.3.3 Refrigerated Air Circulating Fans

Where circulation of air is dependent on a single fan and motor, access arrangements are to be such that the fan and motor can be readily removed for repair or renewal even when the chamber is loaded with refrigerated cargo.

Where several fans and motors are installed and the chamber temperature can be maintained in an allowable range even if one unit is out of use, the above requirement is not applied.

2.3.4 Automatic Temperature Regulating Devices

Where automatic regulating devices for controlling the temperatures in the refrigerated chambers are provided, a manually operated regulating valve or system is to be provided as stand-by service. Alternatively, two sets of automatic regulating systems so arranged that each system can be readily operated by changing over may be provided.

2.3.5 Temperature Difference

In bulk refrigerated cargo ships, the temperature difference between the refrigerated chamber and the refrigerant is to be controlled so that the dehydration of cargo and frosting of the cooling appliances in each chamber can be minimized.

2.3.6 Galvanizing of Brine Tanks and Pipes

Internal surfaces of brine tanks and pipes exposed to brine are not to be galvanized. However, this requirement is not applied where brine tanks are closed type and they are provided with a ventilating pipe or pipes led to the open air in a location where no damage will arise from the gas discharged and their open ends are fitted with non corrosive metallic wire gauze diaphragms, or where the tanks are open type and the compartments in which they are situated are efficiently ventilated

2.3.7 Corrosion Protection of Refrigerant Pipes in Refrigerated Chambers

External surfaces of primary refrigerant or brine pipes of steel within refrigerated chambers or embedded in insulation thereof are to be suitably protected from corrosion by galvanizing, coating of any corrosion protective paint or other methods. Where pipes are connected by screwed couplings or by welding, ungalvanized or uncoated portions of the pipes are to be coated with an efficient corrosion resisting material after pressure testing.

2.4 Other Arrangements in Refrigerated Chambers

2.4.1 Defrosting Arrangements

Where refrigerated chambers are operated below 0°C, means for effectively defrosting air cooler coils in Refrigerated chambers are to be provided.

2.4.2 Ventilating Arrangements in Refrigerated Chambers

Where chambers are intended for the carriage of refrigerated cargoes requiring controlled ventilation, air refreshing arrangements are to be provided. In this case, each chamber is to be provided with its own separate inlet and exhaust vent, and each vent is to be provided with an airtight closing appliance. The positions of the air inlet are to be selected to minimize the possibility of contaminated air entering into the chambers.

2.4.3 Heating Arrangements for Fruit Cargoes

Where it is intended to carry fruit cargoes which may be adversely affected by low temperatures into areas where the ambient temperature may become below the carrying temperature, arrangements for heating the chambers are to be provided.

2.5 Refrigerating Machinery Compartments

2.5.1 Condition of Refrigerating Machinery Compartments

Refrigerating machinery compartments are to be provided with efficient arrangements of drainage and ventilation, and separated by gastight bulkheads from the adjacent refrigerated chambers.

Chapter 3 SPECIAL REQUIREMENTS FOR REFRIGERATING MACHINERY USING AMMONIA AS REFRIGERANT

3.1 General

3.1.1 General Requirements

Refrigerating machinery using ammonia as refrigerant is to be of an indirect refrigerating system using brine, and to use *R*717 refrigerant as the primary refrigerant only.

3.1.2 Definition

The definitions of terms which appear in this chapter are to be as specified in the following **(1)** to **(4)**, unless otherwise specified specially in other chapter.

(1) Gas means ammonia gas used as the refrigerant.

(2) Gas purging means the discharge of noncondensing gases from the condenser.

(3) Storage container means a vessel used for storing gas for replenishment.

(4) Gas expulsion system means the system for excluding gas quickly from a compartment, and consists of ventilation system, gas absorption system, water screening system, gas absorption water tanks, etc.

3.1.3 Drawings and Data

Drawings and data to be submitted in addition to those specified in other chapters, are generally as follows:

(1) Gas Detector Arrangement

(2) General Arrangement of Refrigerating Machinery Compartment

3.2 Design

3.2.1 General Requirements

1. Pressure vessels used in the refrigerating machinery are to be in accordance with the requirements of Group specified in **Chapter 10, Part 7**, and the primary refrigerant pipes (hereinafter referred to as refrigerant pipes) are to be classified into Group I piping specified in **Chapter 12, Part 7.**

2. Refrigerating machinery is to be provided with auxiliary receivers of adequate capacity so that repairs and maintenance may be carried out without discharging the gas to the atmosphere. However, the auxiliary receivers can be dispensed with, if at least the refrigerant in the receiver with the largest capacity can be stored in some other receiver.

3.2.2 Materials

1. Materials capable of highly corrosion (copper, zinc, cadmium, or their alloys) and materials containing mercury are to be not used at locations where ammonia comes in contact.

2. Nickel steel is not to be used in pressure vessels and piping systems.

3. Cast iron valves are not to be used in the refrigerant piping system.

4. Material for sea-water cooled condensers is to be selected considering the corrosion due to sea water.

3.3 Refrigerating Machinery

3.3.1 Refrigerant Compressors

Refrigerant compressors are to be provided with means for automatically stopping the compressor when the pressure on the high pressure side of the refrigerant piping system becomes excessively high. Also, an alarm system which generates visible and audible alarms when this means are in operation is to be installed in the refrigerating machinery compartment and monitoring position.

3.3.2 Piping Joints

Piping joints for the refrigerant piping system are to be butt welded as far as practicable.

3.3.3 Pressure Relieving Devices

The refrigerant gas discharged from a pressure relief valve is to be absorbed in water, except when leading the gas to the low pressure side.

3.3.4 Liquid Level Gauges

If liquid level gauges made of glass are used at locations where pressure exists permanently, they are to comply with the requirements given below.

(1) Flat Type glass is to be used in the liquid level gauges, and the construction is to be such that the gauge is adequately protected against external impacts.

(2) The construction of the stop valve for the liquid is automatically cut off if the glass breaks.

3.3.5 Gas Purging

Gas discharged from the purging valve is to be not discharged directly to the atmosphere, but absorbed in water.

3.3.6 Condenser

Independent piping for discharge of cooling sea water for the condenser is to be used. The piping is to be led directly overboard without passing through accommodation spaces.

3.4 Refrigerating Machinery Compartment

3.4.1 Construction and Arrangements

1. The compartment where the refrigerating machinery and storage vessels are installed (hereinafter referred to as "refrigerating machinery compartment") is to be a special compartment isolated by gastight bulkheads and decks from all other compartments so that leaked ammonia does not enter other compartments. The refrigerating machinery compartment is to be provided with access doors which comply with the following requirements:

(1) At least two access doors are to be provided in the refrigerating machinery compartment as far apart as possible from each other. At least one access door is to lead directly to the weather deck. However, if it is not possible to provide access door directly to the weather deck, then at least one access, is to have air-lock type doors.

(2) Access doors not leading to weather deck are to be of high tightly and self-closing type.

(3) Access doors are to be capable of being easily and are to open outward.

2. The refrigerating machinery compartment is to be not adjacent to accommodation spaces, hospital room or control room.

3. Passages leading to the refrigerating machinery compartment are to comply with the following requirements:

(1) If a passage is adjacent to accommodation spaces, hospital room or control room, it is to be isolated by gastight bulkheads and decks.

(2) The passage is to be isolated from passages to accommodation spaces, and led directly to the weather deck.

4. Penetrations on gastight bulkheads and decks where cables and piping from the refrigerating machinery compartment pass through are to be of gastight construction.

5. Drain pans of adequate size are to be provided at a position which is lower than the refrigerating machinery and storage vessels in the refrigerating compartment so that liquid ammonia does not leak outside the compartment.

6. An independent drainage system is to be provided in the refrigerating machinery compartment is not discharged into open bilge wells or bilge ways of other compartments.

3.5 Gas Expulsion System

3.5.1 General

A gas expulsion system consisting of ventilation system, gas absorption system, water screening system, and gas absorption water tanks is to be installed in the refrigerating machinery compartment so that the gas leaked out accidentally can be expelled quickly from the refrigerating machinery compartment.

3.5.2 Ventilation System

1. A mechanical ventilation system, which complies with the following requirements as a rule, is to be installed in the refrigerating machinery compartment so that this space can be ventilated all the time.

(1) The ventilation system is to have adequate capacity to ensure at least 30 air changes per hour in the refrigerating machinery compartment.

(2) The ventilation system is to be independent of other ventilation systems on board the ship, and is to be capable of being operated from outside the refrigerating machinery compartment.

(3) Exhaust outlets are to be installed at a horizontal distance of more than 10 *m* from the nearest air intake opening, openings of accommodation spaces, services spaces and control stations, and at a vertical distance of more than 4m from the weather decks.

(4) The air intake opening is to be provided at a low position and the exhaust opening is to be provided at a high position in the refrigerating machinery compartment so that the gas does not accumulated in the compartment and the exhaust ducts.

(5) Exhaust fans and the exhaust ducts in which the fans are installed, are to be of a construction such that sparks are not generated according to any of the **(a)** to **(c)** mentioned below.

(a) Either the impeller or the casing, or both, are made of non-electrostatic, non metallic materials.

(b) Non-ferrous metallic material is used in the impeller and the casing

(c) In case where ferrous material is used in the impeller and the casing, the tip clearance is greater than 13mm. However, use of combination of aluminum or magnesium alloy with ferrous materials has possibilities of generating sparks regardless of the tip clearance; therefore, such materials are not to be used in the refrigerating machinery compartment. As a rule, motors for driving the fans are to be of the exterior mount type.

2. Independent ventilation systems are to be installed in passages leading to the refrigerating machinery compartment. However, if the ventilation system specified in-**1** above is provided with ducts so that it can be used for exhausting air in the passages, then an independent ventilation system need not be installed.

3.5.3 Gas Absorption System

A gas absorption system satisfying any of the requirements given below, capable of excluding leaked gases quickly from the refrigerating machinery compartment, and capable of being operated from outside the compartment, is to be installed.

(1) Scrubber

(a) The scrubber is to be design with an adequate processing capacity which restricts the gas concentration at the exhaust fan to well below 25 *ppm*, and absorbs ammonia in the largest receiver within 30 *minutes*.

(b) The pump for the scrubber is to star automatically when the gas concentration in the refrigerating machinery compartment exceeds 300 *ppm*.

(2) Water sprinkle system

(a) The quantity of sprinkled is to be such that the leaked gas can be satisfactorily absorbed.

(b) When the gas concentration in the refrigerating machinery compartment exceeds 300ppm, the pump for sprinkling water is to start automatically.

3.5.4 All Water Screening System

All doors of the refrigerating machinery compartment are to be provided with water screening system which can be operated from outside the compartment.

3.5.5 Gas Absorption Water Tanks

Gas absorption water tanks complying with the requirements given below, are to be installed at a position lower than the refrigerating machinery compartment so that the leaked liquid ammonia can be recovered quickly.

(1) The tank is to have such that the water which can absorb the refrigerating filled in at least one refrigerating machinery can be fully recovered.

(2) An automatic water supply system is to be installed in the tank so that the fully-filled condition of the tank is always maintained.

(3) Overflow from the tank is to be diluted or neutralized and then discharged overboard directly, without leading the discharge pipes through accommodation spaces.

(4) Means are to be provided in the tank to recover the drain of the liquid ammonia generated in the refrigerating machinery compartment. An appropriated drain cup is to be provided to prevent reverse flow of the gas from the tank.

(5) All the vent pipe of the tank is to be connected to the exhaust pipe of ventilation system of **3.5.2.**

3.6 Gas Detection and Alarm System

3.6.1 Installation Requirements

1. Gas detection and alarm systems are to be provided in the refrigerating machinery compartment complying with the following requirements:

(1) At least one gas detector complying with the requirements given below is to be installed above each refrigerating machinery.

(a) The detectors are to active an alarm when the gas concentration exceeds 25 *ppm*

(b) When the gas concentration exceeds 300 *ppm*, the detector is to automatically stop the refrigerating machinery, automatically activate the gas expulsion, and activate the alarm.

(2) An adequate number of flammable gas detectors are to be provided so that when the gas reaches up to 4.5%, to power supply to the electrical equipment in the refrigerating machinery compartment is cut off and the alarm systems are activated.

(3) The alarm system are to generate visible and audible alarms near the doors, within and outside the refrigerating machinery compartment and at monitoring locations.

(4) A manually-operated transmitter for leakage warnings is to provided, near the doors and outside the refrigerating machinery compartment.

2. Gas detection and alarm system complying with the following requirements are to be provided in passages leading to the refrigerating machinery compartment:

(1) The gas detectors are to activate the alarm system when the gas concentration exceeds 25 *ppm*.

(2) The alarm systems are to generate visible and audible alarms in the passage and near the doors of the refrigerating machinery compartment.

3. Detectors are to be capable of continuous detection and considered to be appropriated by the Society.

3.7 Electrical Equipment

3.7.1 General

1. Electrical equipment in the refrigerating machinery compartment required to be operated in the event of leakage accidents, gas detection and alarm system, and emergency lights are to be certified safety types for use in the flammable atmosphere concerned.

2. Electrical equipment in the refrigerating machinery compartment other than mentioned in-**1** above, are required to switch off automatically, by means of circuit breakers installed outside the refrigerating machinery compartment when the flammable gas detector specified in **3.6.1-1(2)** activates.

3. If a water sprinkler system in installed in the refrigerating machinery compartment as the gas absorption system, all electrical machinery compartment are to be of the waterproof type.

3.8 Safety and Protective Equipment

3.8.1 General

As a rule, safety and protective equipment as given below are to be provided, and are to be stored at locations outside the refrigerating machinery compartment so that they can be easily retrieved in the event of leakage of the refrigerant. Storage locations are to be marked with signs so that they can be identified easily.

(1) Protective clothing (helmet, safety boots, gloves, etc) x 2

(2) Self-contained breathing apparatus (capable of functioning for at least 30 minutes) x2

(3) Protective goggles x2

(4) Eye washer x1

(5) Boric acid

(6) Emergency electric torch x2

(7) Electric insulation resistance meter x1

Chapter 4 REFRIGERATED CHAMBERS

4.1 Construction of Refrigerated Chambers

4.1.1 Materials used for Refrigerated Chambers

Decks, floors and boundary bulkheads between refrigerated chambers are to be constructed of materials confirmed to be airtight. However, divisional bulkheads between refrigerated chambers, where the chambers concerned are intended for cargo which will not taint or adversely affect the cargo in any other chamber, may be constructed of appropriated materials subjects to the approval of the Society.

4.1.2 Air tightness of Closing Appliances

Closing appliances such as hatch covers, access doors, bilge and manhole covers forming part of the insulated envelope of independently refrigerated chambers, are to be made airtight. Where hatch covers or plugs are exposed to the ambient conditions, they are to be provided with a double seal.

4.1.3 Welding and Materials of Steel works in Refrigerated chambers

Special attention is to be paid to welding and materials of members which are directly welded to the main structural hull members, and structural discontinuities and/ or defects in welded joint are to be avoided.

4.1.4 Comings of Manholes, etc.

Tank top insulation in way of manholes and bilge hats is to be provided with a liquid tight coming with a suitable height to prevent into the insulation.

4.1.5 Penetration of Ventilation Ducts and Pipes through Decks, Bulkheads, etc.

1. Ventilation ducts are not to pass through the collision bulkheads below the freeboard deck. Ducts passing through the other water tight bulkheads are to be provided with an efficient closing appliance which can be operated from a position above the freeboard deck accessible at all times. In the operating position, an indicator is to be provided to show whether the duct is opened or closed.

2. Refrigerating pipes passing through bulkheads or decks of refrigerated chambers are not to be in direct contact with the steel work. Air tightness of the bulkheads, the fittings and packing of the glands are to be both fire resisting and watertight.

3. Ventilators, air ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight in way of penetrating parts of insulation, and they are to be effectively insulated in the refrigerated chamber.

4. Air pipes, sounding pipes, bilge suction pipes and other pipes led from the outside of refrigerated chamber. Passing through refrigerated chambers are to be effectively insulated and special consideration is to be given to the arrangement of these pipe lines to prevent freezing of liquid in these pipes.

4.1.6 Insulating Linings, etc.

Insulation linings, bilge limbers and their covers, hatch covers and access doors to refrigerated chambers are to be constructed of water-vapour-resisting material or covered with such material.

4.1.7 Cargo Battens

Cargo battens are to be fitted and so arranged on all vertical walls of refrigerated chambers as to provide sufficient space for air circulation and prevent the cargo from coming to contact with the insulation or cooling grids. However, where the form of insulation lining storage method of cargo, etc. are adequate, and need not provided battens, they may not be required.

4.1.8 Gratings

Gratings of suitable form and strength are to be provided on floors of refrigerated chambers so as to provide sufficient space between floors and cargo for free air circulation and prevent the floor mechanical damage by cargo handling. However, where the floor insulation lining meets the above requirements or cargoes to be loaded are suspended or supported on suitable pallets, gratings are not required.

4.2 Insulation and Insulation Materials

4.2.1 Insulation Materials

1. Insulation materials approved or accepted by the Society are to be used.

2. If slab formed insulant is used, it is to have suitable strength. Where a binder is used to join slabs each other, it is to be odourless and not to absorb any of the odours from the cargo.

4.2.2 Protective Coatings

1. Steel works to be insulated are to be thoroughly cleaned and coated with an anti-corrosive composition before they are insulated.

2. All steel bolts, nuts and other fixtures which support or secure insulation materials, joints, coverings, etc. are to be galvanized or protected against corrosion with suitable means.

4.2.3 Insulation

1. The thickness of insulation is to be strongly fixed so as not to be loose. Where the insulation if of slab form, the joints are to be butted closely together and staggered. Unavoidable crevices area to be filled with suitable insulating material.

2. Structural members which extend into refrigerated are to be effectively insulated over a sufficient length in the refrigerating chambers to prevent heat penetration into the chambers and super cooling of each member at the place of penetration.

4.2.4 Removal of Insulation

1. The insulation of such places that easy access to bilges, bilge suction roses and tank manhole lids is required is to be of plug type and removable.

2. The insulation in way of bilge suction pipes, air and sounding pipes and other pipe lines is to be removable to the extent necessary for access for inspection.

4.2.5 Insulation of Oil Tank Plating

Where the tank top and bulkhead of the oil storage tank form part of the refrigerated chamber walls, air space of sufficient width is to be provided between the tank plating and the insulation is fitted. Where air space is provided between the tank plating and the insulation, free drainage of oil seepage to the gutter way and bilges is to be ensured. Fur there more, such air spaces are to be spaces are to be provided with ventilating pipes led to the open air, and corrosion resisting metallic wire gauze diaphragms are to be fitted at the outlet.

4.3 Temperature Measuring Arrangements

4.3.1 Number of Thermometers and Sensors

1. Two sets of thermometers are to be provided in each refrigerated chamber. At least two sensors are to be connected to each set of thermometers for each chamber.

2. Unless otherwise required, at least the following numbers of sensors are to be provided in each chamber, depending upon the volume of the chamber.

(1) Volume up to 300 m^3: 4

(2) Volume up to 600 m^3: 5

(3) Volume above to 600 m^3: 5 plus one for each 400 m^3 or fraction thereof.

3. In addition to those specified in-**2,** one sensor is to be fitted in each main stream of air in the suction and delivery sides of each air cooler.

4.3.2 Electric Thermometers

1. Electric power supply to each instrument in refrigerated chambers is to be fed by a separated final sub-circuit.

2. Sensors connected to thermometers in refrigerated chambers are to be properly protected from mechanical damage.

3. The readings of thermometers in refrigerated chamber are to be accurate to the true temperature within $\pm$ 0.5ºC in the range of below 0ºC, and $\pm$ 0.3ºC in the range of °C and above.

4.4 Drainage Arrangements

4.4.1 General

1. Drainage arrangements are to be in accordance with the relevant requirements in **13.5, Part 7** in addition to the requirements in this Section.

2. All refrigerated chambers and air coolers are to have ample continuous drainage

3. Compartments outside the refrigerated chambers are not to drain into the refrigerated chambers.

4.4.2 Non-return Valves and Sealed Traps in Scupper Pipes

1. Scupper pipes led from refrigerated chambers and air cooler trays are to be provided with non-return valves and liquid sealed traps. However, the pipes led from between deck chambers and air cooler trays above the tank top may be provided with only sealed traps.

2. Where scupper pipes from refrigerated chambers and air cooler trays are connected to a common header, each branch pipe is to be provided with liquid sealed trap, and those from lower hold spaces are to be fitted, in addition, with non-return valves.

3. Where the chambers temperature contemplated is 0ºC or below, scupper pipes together with non-return valves and liquid sealed traps specified in **-1** and **-2** are, if necessary, to be well insulated.

4. Liquid sealed traps are to have an adequate depth and arranged so as to be accessible for cleaning and refilling with liquid.

Chapter 5 TESTS

5.1 Tests at the Manufacturer's Works

5.1.1 Pressure Tests and Leak Tests

1. Machinery components, pressure vessels and pressure piping exposed to a primary refrigerant pressure are to be subjected to hydrostatic tests to a pressure of 1.5 *times* the design pressure. After hydrostatic tests, they are to be leak tested to pressure equal to the design to the pressure.

2. Machinery components, pressure vessels and pressure piping intended for use with brine are to be subjects to hydrostatic tests to a pressure of 1.5 *times* the design pressure or 0.4 *MPa* whichever is the greater.

3. In general, pressure tests are to be carried out with water or oil and leak tests are to be carried be out with air or suitable inert gases or any inert gas with a small amount of the refrigerating added to it.

5.1.2 Performance Tests

1. Compressors, fans, primary refrigerant or brine pumps and their prime movers are to be tested for their performance.

2. Welded parts in pressure vessels and piping are to be tested in accordance with the relevant requirements in **Chapter 11, Part 7.**

3. Electrical equipment is to be tested in accordance with the requirements in **Chapter 2, Part 8.**

5.2 Tests during Construction

5.2.1 Leak Tests

1. The primary refrigerant system is to be leak tested after the piping arrangement added, to a pressure of 90% of the respective design pressure.

2. The brine system is to be leak after the piping arrangement is completed on board the ship to a pressure of 1.5 times the maximum working pressure of the brine pump or 0.4 MPa whichever is the greater.

5.2.2 Calibration of Thermometers

Thermometers are to be checked for accuracy at the freezing point of water, after they are set up on board the ships, and their accuracy is to comply with the required specification. The records of checking are to be submitted to the Surveyor.

5.2.3 Air Circulation Tests

Where air circulating fans are provided in refrigerated chambers, it is to be ascertained that the velocity of circulating air and the state of air circulation are satisfactory.

5.2.4 Functional Tests

Automatic control devices, safety devices and alarms are to be ascertained that they operate satisfactorily.

5.2.5 Test under Operating Condition

All components of the refrigerating machinery are to be operated under full load condition as far as possible, and be proved that there is no defect on the installation, and changing over to stand-bay units is smooth. This test may be carried on the cooling down stage at the heat balance test specified in **5.2.6.**

5.2.6 Heat Balance Tests

Heat balance tests are to be carried out in the way specified in the following **(1)** to **(4),** in order to measure the mean heat leakage from the insulation of refrigerated chambers.

(1) The chambers are to be cooled down step by step to a temperature lower than at least 20ºC from the atmospheric temperature. Further, cooling is to be continued until the chamber temperature can be maintained substantially constant without any adjustment of the output of the machinery or with regular on-off operation of the working compressors.

(2) After the stabilization stated above has been obtained, necessary measurements are to be taken once an hour for at least six hours, keeping the chamber temperature substantially constant.

(3) It is to be ascertained that the heat leakage obtained by this test is not more than the designed value calculated from the refrigerating capacity with reasonable redundancy, and the test was properly carried out. The measuring records are to be submitted to the Surveyor.

(4) Where the chamber temperature, the chamber is to be cooled down to the specified temperature at the thermal balance test is higher than the specified temperature, the chamber is to be cooled down to the specified temperature and keep the condition for not less than two hours. During the period it is to be ascertained that the operation of the whole installation is smooth and satisfactory.

5.2.7 Defrosting Test

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