Contents

RULES FOR CARGO REFRIGERATING INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope*

1 The Rules for Cargo Refrigerating Installations (hereinafter referred to as "the Rules") 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 NIPPON KAIJI KYOKAI (hereinafter referred to as "the Society") intended to be registered under **Chapter 3 of the Regulations for the Classification and Registry of Ships**.

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*134*a* : CH_2FCF_3
*R*404*A* : *R*125/*R*143*a*/*R*134*a* (44/52/4 *wt*%) CHF_2CF_3 / CH_3CF_3 / CH_2FCF_3
*R*407*C* : *R*32/*R*125/*R*134*a* (23/25/52 *wt*%) CH_2F_2 / CHF_2CF_3 / CH_2FCF_3
*R*407*H* : *R*32/*R*125/*R*134*a* (32.5/15/52.5 *wt*%) CH_2F_2 / CHF_2CF_3 / CH_2FCF_3
*R*410*A* : *R*32/*R*125 (50/50 *wt*%) CH_2F_2 / CHF_2CF_3
*R*449*A* : *R*32/*R*125/*R*1234*yf*/*R*134*a* (24.3/24.7/25.7/25.3 *wt*%) CH_2F_2 / CHF_2CF_3 / $CF_3CF=CH_2$/CH_2FCF_3
*R*507*A* : *R*125/*R*143*a* (50/50 *wt*%) CHF_2CF_3 / CH_3CF_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 At the request of the shipowner or his representative, the Surveyor may carry out Loading Port Surveys on registered refrigerating installations at the loading port in accordance with the requirements in **Chapter 7** of the Rules. On completion of the survey to the satisfaction of the Surveyor a Certificate on Loading Port Survey will be issued.

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

6 The relevant requirements in **the Rules for the Survey and Construction of Steel Ships** 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 can not 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.

1.1.4 Installation Characters

1 The refrigerating installations to be registered in accordance with the Rules (excluding the installations specified in the next **-2**) will be distinguished by the character **RMC*** or **RMC**.

2 The refrigerating installations equipped with controlled atmosphere systems to be registered in accordance with the Rules will be distinguished by the character **RMC*・CA** or **RMC・CA**.

1.1.5 Installation Notations

1 In General, Installation Characters will be followed by the minimum temperature(s) in the refrigerated chambers to be maintained with sea temperature maximum.

e.g. -25℃/32℃ *for No. A, B and C Chambers and* -15℃/32℃ *for No. D and E Chambers*.

(note) -25℃ or -15℃ indicate the minimum chamber temperatures to be maintained and 32℃ the maximum sea temperature.

2 When an installation is provided with any additional equipment to suit for carriage of special cargoes or quick freezers for the catch in fishing vessels, appropriate notations will be added to the Installation Character upon application of the Owner.

e.g. *Equipped for carriage of fruit*

Equipped with quick freezers

3 When an installation is provided with the fixed N_2 generator as a part of controlled atmosphere system, the Installation Notation will be affixed as follows;

e.g. *Equipped with fixed N_2 generator*

4 When controlled atmosphere systems are installed for the certain holds only, appropriate notations will be affixed as follows;

e.g. *Equipped for No. F and G Holds*

5 When the Society considers necessary to distinguish and special features or usage limitation of the installation, other appropriate notations than those described in **-1** to **-4** will be affixed to the Installation Character.

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(1) (*MPa*)	Low Pressure side(2) (*MPa*)
*R*134a	1.4	1.1
*R*404*A*	2.5	2.0
*R*407*C*	2.4	1.9
*R*407*H*	2.5	2.0
*R*410*A*	3.3	2.6
*R*449*A*	2.6	2.0
*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 SURVEYS

2.1 General

2.1.1 Kinds of Surveys

Kinds of surveys are as follows:

(1) Surveys for Registration (hereinafter referred to as "Registration Surveys")

Registration surveys include the following:

(a) Registration Surveys during Construction

(b) Registration Surveys not Built under the Survey

(2) Surveys for registration maintenance (hereinafter referred to as "Registration Maintenance Surveys")

Registration Maintenance Surveys include the following.

(a) Special Surveys

(b) Annual Surveys

(c) Occasional Surveys

(d) Unscheduled Surveys

2.1.2 Registration Surveys and Intervals of Registration Maintenance Surveys*

1 Registration Surveys

(1) Registration Surveys during Construction

Refrigerating installations intended to be constructed and registered with the Society under the survey by the Surveyors in accordance with the designs approved by the Society are to undergo the Registration Survey during Construction. The presence of the Surveyor is required at the following stages of the work.

However, except the case of thermal balance test specified in **6.2.6** of the Rules, the requirements may be modified having regard to the actual status of facilities, technical abilities and quality control at the works.

(a) When the tests of materials in accordance with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships** and other tests necessary for the approval or acceptance described in **3.1.3-4**, **5.2.1-1** and **5.2.5** of the Rules are carried out.

(b) When materials are appropriated for parts, or when such parts are appropriated for the refrigerating installations concerned.

(c) When finishing an important part is completed, and if necessary, at a proper time during the middle stage of construction.

(d) When the tests specified in **Chapter 6** are carried out.

(2) Registration Surveys not Built under the Survey

Refrigerating installations intended to be registered in a way other than that described in **(1)** above are to undergo the Registration Survey when an application for the survey is made.

2 Registration Maintenance Surveys

Refrigerating installations which have been registered are to undergo surveys in accordance with the following intervals to maintain their registrations.

(1) Special Surveys are to be carried out at intervals specified in **1.1.3-1(3), Part B of the Rules for the Survey and Construction of Steel Ships**.

(2) Annual Surveys are to be carried out at intervals specified in **1.1.3-1(1), Part B of the Rules for the Survey and Construction of Steel Ships**.

(3) An Occasional Survey: At a time falling on any of **(a)** to **(d)** mentioned below, independently of special surveys and annual surveys. To implement the survey, in lieu of the traditional ordinary surveys where a surveyor is in attendance, the Society may approve survey methods which it considers to be appropriate.

(a) When main parts of the installations have been damaged, repaired or renewed.

(b) When the installations are modified or altered.

(c) When it is considered necessary by the Society that an important part of the installation should be repaired at a time other

than date for the special or annual survey.

(d) When a survey is needed for a reason other than the above.

(4) The classed ships may be subject to Unscheduled Surveys when the confirmation of the status of the installations by survey is deemed necessary in cases where the Society considers the installations to be subject to **1.4-3 of the Conditions of Service for Classification of Ships and Registration of Installations**.

2.1.3 Special Surveys and Annual Surveys Carried out in Advance, etc.

1 Surveys carried out in advance

The requirements for Special Surveys and Annual Surveys carried out in advance are to be in accordance with the provisions specified in **1.1.4, Part B of the Rules for the Survey and Construction of Steel Ships**.

2 Postponement of Special Surveys

The requirements for postponement of Special Surveys are to be in accordance with the provisions specified in **1.1.5-1(1)** or **1.1.5-1(2), Part B of the Rules for the Survey and Construction of Steel Ships**.

3 Partial Omission of Surveys

At Special Surveys, the Surveyor may omit the thorough examination for items examined in accordance with the requirements for the Special Survey at the previous Annual Survey or Occasional Survey at his discretion.

4 Modification of Surveys

At Special Surveys, the Surveyor may modify the requirements for cargo refrigerating installations specified in **2.3.1**, taking into account the size, purpose, construction, history, results of the previous Survey and the present conditions of the installations.

5 Continuous Surveys

(1) For machinery and equipment approved to be applicable by the Society, where they are examined in regular rotation to complete all the requirements of the special survey within 5 *years* and the intervals of consecutive surveys of each item do not exceed 5 *years*, the examination of them in special surveys may be properly modified at the discretion of the Surveyor.

(2) The survey in such way as specified in **(1)** above is referred to as a continuous survey.

2.1.4 Preparation for Surveys and Others

1 All such preparations as required for the survey to be carried out as well as those which may be required by the Surveyor as necessary in accordance with the requirements in the Rules are to be made by the applicant of the survey. The preparations are to include provisions of an easy and safe access, necessary facilities and necessary records for the execution of the survey. Inspection, measuring and test equipment, which Surveyors rely on to make decisions affecting classification are to be individually identified and calibrated to a standard deemed appropriate by the Society. However, the Surveyor may accept simple measuring equipment (*e.g.* rulers, measuring tapes, weld gauges, micrometers) without individual identification or confirmation of calibration, provided they are of standard commercial design, properly maintained and periodically compared with other similar equipment or test pieces. The Surveyor may also accept equipment fitted on board a ship and used in examination of shipboard equipment (*e.g.* pressure, temperature or rpm gauges and meters) based either on calibration records or comparison of readings with multiple instruments.

2 The applicant for survey is to arrange a supervisor who is well conversant with the survey items intended for the preparation of the survey to provide the necessary assistance to the Surveyor according to his requests during the survey.

3 The survey may be suspended where necessary preparations have not been made, any appropriate attendant mentioned in the previous **-2** is not present, or the Surveyor considers that the safety for execution of the survey is not ensured.

4 Where repairs are deemed necessary as a result of the survey, the Surveyor will notify his recommendations to the applicant of the survey. Upon this notification, the repair is to be made to the satisfaction of the Surveyor.

5 In cases where it is necessary to replace any fittings, equipment or parts, etc. used onboard, replacements are to comply with the regulations to be applied during ship construction. However, in cases where new requirements are specified or where deemed necessary by the Society, the Society may require that such replacements comply with any new requirements in effect at the time the relevant replacement work is carried out. In addition, replacements are not to use any materials which contain asbestos.

2.1.5 Laid-up Ships

1 Laid-up ships are not subject to Registration Maintenance Surveys. However, Occasional Surveys may be carried out at the request of owners.

2 When laid-up ships are about to be re-entering service, the following surveys and surveys for specific matters which have been postponed due to being laid-up, if any, are to be carried out.

(1) If the due dates for Registration Maintenance Surveys have not transpired while the ship was laid-up, then an equivalent to the Annual Surveys specified in 2.3.2 is to be carried out.

(2) If the due dates for Registration Maintenance Surveys have transpired while the ship was laid-up, then Registration Maintenance Surveys are, in principle, to be carried out. However, in cases where Special Surveys and Annual Surveys are due, only the Special Survey may be carried out.

2.2 Registration Surveys

2.2.1 Registration Surveys during Construction*

1 In a Registration survey during construction, the construction, materials, scantlings and workmanship of the refrigerating installation are to be satisfied with the full requirements of each chapter concerned of the Rules.

2 The refrigerating machinery used in the refrigerating installation intended to be registered with the Society may be acceptable without their related tests by confirming the certificate issued by the Society.

3 For the refrigerating installation intended to undergo a registration survey during construction, the plans and documents specified in **(1)** to **(15)** are to be submitted to the Society before the work is commenced.

(1) Specifications of the refrigerating installation (including particulars of refrigerating machinery units).

(2) Thermal calculation sheets.

(3) General arrangements of the refrigerating machinery (including detailed ventilating arrangements).

(4) Sectional assembly of refrigerant compressors and detailed plans (material to be indicated) of reciprocating compressor crankshafts, or rotors of screw type compressors, or rotors, discs and casings of turbo compressor, and plans of speed-increasing gear.

(5) Detailed plans of pressure vessels subject to the primary refrigerant pressure (condensers, receivers, evaporators (brine coolers), oil separators, surge tanks, inter coolers, etc.).

(6) Piping arrangements of primary and secondary refrigerants and cooling water (materials, diameter and thickness of pipes are to be indicated).

(7) Arrangements of refrigerated chambers (including ductings for air circulation and ventilation).

(8) Wiring diagram for the refrigerating installation and arrangements of electric appliances.

(9) Wiring diagram in refrigerated chambers (including details of construction of penetration of the insulation).

(10) Kind of insulation on all surfaces, physical properties, thickness and methods of attachment of the insulation and linings (including detailed construction and insulating methods of hatch covers, access doors, ventilating ducts, scupper and bilges).

(11) Drainage arrangements and defrosting arrangements in refrigerated chambers and spaces in which the air coolers are installed.

(12) Arrangements of thermometers or sensors in refrigerated chambers and air coolers, and the name of manufacturer and the type of the sensors are to be informed.

(13) Explanatory documents to show the function of automatic temperature controls.

(14) Heat balance tests and measuring plans (performance diagrams of compressors, fans, and their driving motors are to be submitted as well).

(15) Other documents considered necessary by the Society.

4 Asbestos-free declarations and supporting documents is to be submitted to the Society for reference in addition to the approval plans and documents specified in -3 above.

5 The plans and documents specified in -3 and -4 above are to be submitted the Society in accordance with **(1)** to **(3)** below.

(1) Where the submission of plans and documents by paper, 2 sets for the Society and necessary sets for returning to the applicant are to be submitted.

(2) Where the submission of plans and documents electrically, the plans and documents are to be submitted using the systems prepared by the Society.

(3) Where the submission of plans and documents by means other than **(1)** and **(2)** above, the plans and documents are to be submitted by the means deemed appropriate by the Society.

2.2.2 Registration Surveys Not Built under the Survey*

1 General

In a Registration Survey not built under the survey, the refrigerating installation is to be examined on their construction, materials, workmanship and actual conditions as required for the special survey corresponding to their age, in order to ascertain their effectiveness.

2 Tests

In the Registration Survey not built under the survey, operation tests and other various tests are to be carried out in accordance with the requirements in **Chapter 6**. However, the heat balance test may be replaced with other test or omitted where the Surveyor approves it.

3 When a refrigerating installation is intended to undergo the Registration Survey not built under the survey, plans and documents are to be submitted as may be required by the requirements in **2.2.1**.

2.3 Registration Maintenance Surveys

2.3.1 Special Surveys*

At a special survey, the examinations required by the following **(1)** to **(18)** are to be carried out.

(1) An examination of the refrigerating installation log book is to be made to trace the operating condition of the installation during navigation.

(2) Insulation linings and their fastening are to be examined. Any indication of dampness or deterioration of the insulation is to be investigated.

(3) Air circulation ducts, hatch covers and their seal, access doors and their fastening, ventilating system and their closing means are to be examined. Care is to be given to the condition of penetrating parts where ducting or ventilating pipes pass through the deck plating.

(4) Bilge ways, wells, strainers, suction and sounding pipes, scupper pipes together with non-return valves and water sealed traps fitted to them are to be cleaned and examined. Air cooler defrosting arrangements and their drainage arrangements are also to be examined.

(5) Condition of air coolers' cooling coils, cooling grids (including brine) in refrigerated chambers is to be examined.

(6) Shells of condensers, receivers, evaporators, separators, driers, filters and other pressure vessels exposed to the primary refrigerant pressure, and their connections and piping are, as far as possible, to be examined externally.

(7) Insulation on the surfaces of pressure vessels, pipe connections and piping is to be examined for dampness or deterioration.

(8) Reciprocating compressors with their lubricating system are to be opened up and examined. In the case of screwed-type compressors or compressors deemed appropriate by the Society, the interval of opening up may be modified by the Society, provided their working condition is found satisfactory.

(9) Condenser cooling water pumps, primary refrigerant pumps and brine pumps are to be opened up and examined.

(10) Insulated pipes carrying the refrigerant are to be examined both outside and inside the insulated chambers, removing the insulation to the extent necessary for checking their condition, especially of the locations in which pipes are connected by butt welding in place or screwed couplings.

(11) All pressure relief valves throughout the refrigerating plant are to be adjusted on their relieving pressures.

(12) All automatic controls, safety devices and alarms are to be tested for their satisfactory function.

(13) Randomly selected thermometers and apparatus used for measuring the temperature in the chambers and of air in suction and delivery main stream are to be checked for their accuracy.

The Surveyor may at his discretion accept the checking records made by some reliable persons.

(14) The insulation in refrigerated chambers is to be carefully examined, and bored where considered necessary in order to determine the integrity and dryness. These test holes are subsequently filled carefully.

(15) Brine pipe system is to be tested to a pressure of 1.5 times the design pressure or 0.4*MPa* whichever is the greater.

(16) Pressure vessels are to be opened up for examination, and afterward pressure tested in accordance with the following procedures:

(a) The coils of gas condensers of the coil-in-casing type are to be examined and tested to a pressure of 1.5 times the high pressure side design pressure. Where it is impracticable to remove the coils they may be examined through inspection holes and tested in place.

(b) The coils of evaporators of the coil-in-casing type are to be examined and tested to a pressure of 1.5 times the low pressure side design pressure. Where it is impracticable to remove the coils, they may be examined through inspection holes and

tested in place.

(c) Gas condensers of the shell-and-tube type and gas evaporators (brine coolers) of the shell-and-tube type in which the primary refrigerant is in the shell, are to have the water or brine end covers removed and the tube plates, tube ends and inside the end covers examined. Afterwards, the shells are to be tested to a pressure equal to the high pressure side design pressure.

(d) Gas evaporators (brine coolers) of the shell-and-tube type in which the brine is in the shell are to have the primary refrigerant end covers removed and the tube ends and inside the end covers examined. The shells are to be tested to a pressure of 1.5 times the design pressure or 0.4*MPa* whichever is the greater. After refitting the end covers, the primary refrigerant side is to be tested to a pressure equal to the low pressure side design pressure.

(e) Primary refrigerant receivers are to be hydrostatically tested at the design pressure of the high pressure side. However, when the receivers are designed to use such primary refrigerant as *R*134*a*, *R*404*A*, *R*407*C*, *R*407*H*, *R*410*A*, *R*449*A* or *R*507*A*, or when they are proved to have no harmful defects such as erosions or cracks on the inner surface of the vessels by means of ultrasonic test or other effective non-destructive examinations, the above mentioned pressure test may be omitted.

(f) For pressure vessels for the refrigerant of *R*134*a*, *R*404*A*, *R*407*C*, *R*407*H*, *R*410*A*, *R*449*A* or *R*507*A*, pressure tests specified in **(a)** through **(e)** above may be omitted at the first Special Survey provided that the vessels are found to be in good order.

(17) Current condition of the electrical equipment and electric cables are to be examined. It is to be ascertained that their insulation resistance is not less than 100,000Ω between all insulated circuits and earth. When correct records are maintained, the above examination may be omitted at the discretion of the Surveyors.

(18) Operation tests of the refrigerating installation are to be carried out.

2.3.2 Annual Surveys

At an annual survey, an external examination is to be carried out on the following items **(1)** to **(5)**. Examination may also be made on the items which are prepared to be examined in detail or which are opened up by the Owners' option. If any defects are observed at such examinations, the Surveyor may require open-up examinations of the suspected items.

(1) Items required in **(1)** through **(7)**, and **(13)** in 2.3.1 are to be examined.

(2) Compressors, condenser cooling water pumps, primary refrigerant pumps, brine pumps, air circulation fans and their driving motors are to be examined externally.

(3) Water end covers of condenser(s) selected by the Surveyor are to be examined externally for corrosion through inspection holes or other suitable openings.

(4) Tests for insulation resistance are to be made on the motors and controls of compressors, pumps, fans, etc. and their wiring, and the resistance is to be not less than 100,000Ω between insulated circuits and earth. However, when correct records are maintained, the above tests may be omitted at the discretion of the Surveyor.

(5) Random tests are to be made to ascertain that the automatic controls, safety devices and alarms are in good working condition.

2.3.3 Occasional Surveys*

At an occasional survey, examinations or tests on items required are to be carried out in accordance with the requirements in 2.1.2-2(3), to the satisfaction of the Surveyor. To implement the survey, in lieu of the traditional ordinary surveys where a surveyor is in attendance, the Society may approve survey methods which it considers to be appropriate.

2.3.4 Unscheduled Surveys

At Unscheduled Surveys, investigations, examinations or tests are to be made to the satisfaction of the Surveyor with respect to the matters concerned.

Chapter 3 REFRIGERATING MACHINERY

3.1 General

3.1.1 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*134*a*, *R*404*A*, *R*407*C*, *R*407*H*, *R*410*A*, *R*449*A* or *R*507*A* are to be classified into Group III specified in **12.1.3, Part D of the Rules for the Survey and Construction of Steel Ships**.

5 Pressure vessels for the refrigerant of *R*134*a*, *R*404*A*, *R*407*C*, *R*407*H*, *R*410*A*, *R*449*A* or *R*507*A* are to be classified in accordance with the requirements in **10.1.3, Part D of the Rules for the Survey and Construction of Steel Ships**, according to the design pressure specified in **1.2(5)** of the Rules.

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

3.1.2 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.

3.1.3 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 D of the Rules for the Survey and Construction of Steel Ships** according to the classes of pipes specified in **3.1.1-4** and **4.2.1-1**.

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 D of the Rules for the Survey and Construction of Steel Ships** according to the classes of pressure vessels specified in **3.1.1-5** and **4.2.1-1**.

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 3.1**. 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℃ or higher than 220℃. In this case, such valves may be used at temperatures down to -50℃, even if the design temperature is lower than 0℃, provided that they are used under a pressure up to 1/2.5 of the design pressure.

6 Special materials such as rubber hoses, plastic tubes (including vinyl pipes), aluminium alloys, etc. used for refrigerating machinery is to be approved or accepted by the Society in consideration of the refrigerant used or service conditions.

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

the Survey and Construction of Steel Ships.

Table 3.1 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℃ 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℃ or below.
	Spheroidal graphite iron castings, Malleable iron castings or equivalent thereto	Not to be used for design pressure exceeding 3.2 *MPa*

3.2 Construction, etc. of Refrigerating Machinery

3.2.1 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.

3.2.2 Driving Machines and Gearing

Prime movers and step-up gearing for compressors are to be in accordance with the relevant requirements in **Part D** and **Part H of the Rules for the Survey and Construction of Steel Ships**

3.2.3 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 D of the Rules for the Survey and Construction of Steel Ships** (excluding those in **10.8.3**).

3.2.4 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.

3.2.5 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.

3.2.6 Refrigerating Driers

Driers are to be provided to the refrigerant pipes for *R*134*a*, *R*404*A*, *R*407*C*, *R*407*H*, *R*410*A*, *R*449*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.

3.2.7 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.

3.2.8 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.

3.2.9 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 D of the Rules for the Survey and Construction of Steel Ships**.

2 Pipes and pipe flange couplings are to be in accordance with the requirements for air in **Table D12.10, Chapter 12, Part D of the Rules for the Survey and Construction of Steel Ships**.

3.2.10 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.

5 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.

3.2.11 Automatic Control

Automatic control is to be in accordance with the requirements in **18.2, Part D of the Rules for the Survey and Construction of Steel Ships**.

3.2.12 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 H of the Rules for the Survey and Construction of Steel Ships**.

3.3 Cooling Appliances in Refrigerated Chambers

3.3.1 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.

3.3.2 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.

3.3.3 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.

3.3.4 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.

3.3.5 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.

3.3.6 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.

3.3.7 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.

3.4 Other Arrangements in Refrigerated Chambers

3.4.1 Defrosting Arrangements

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

3.4.2 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.

3.4.3 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.

3.5 Refrigerating Machinery Compartments

3.5.1 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 4 SPECIAL REQUIREMENTS FOR REFRIGERATING MACHINERY USING AMMONIA AS REFRIGERANT

4.1 General

4.1.1 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.

4.1.2 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.

4.1.3 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

4.2 Design

4.2.1 General Requirements

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

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.

4.2.2 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.

4.3 Refrigerating Machinery

4.3.1 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.

4.3.2 Piping Joints

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

4.3.3 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.

4.3.4 Liquid Level Gauge

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 gauge, 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 level gauge is to be such that the flow of liquid is automatically cut off if the glass breaks.

4.3.5 Gas Purging

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

4.3.6 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.

4.4 Refrigerating Machinery Compartment

4.4.1 Construction and Arrangement

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 operated 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 machinery 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 so that the drainage of this compartment is not discharged into open bilge wells or bilge ways of other compartments.

4.5 Gas Expulsion System

4.5.1 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.

4.5.2 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, service spaces and control stations, and at a vertical distance of more than 4 *m* 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 accumulate in the compartment and the exhaust ducts.

(5) Exhaust fans are to be of a construction that does not allow any sparks to be generated. For the purpose of this requirement, as a rule, motors for driving the fans are to be of the exterior mounted 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.

4.5.3 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 designed 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 start automatically when the gas concentration in the refrigerating machinery compartment exceeds 300 *ppm*.

(2) Water sprinkler system

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

(b) Nozzles are to be of type approved by the Society. As a rule, nozzles are to be positioned so that their range covers all the refrigerating machinery in the compartment.

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

4.5.4 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.

4.5.5 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 a capacity that the water which can absorb the refrigerant 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 appropriate 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 the ventilation system of **4.5.2**.

4.6 Gas Detection and Alarm System

4.6.1 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 activate 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 concentration reaches up to 4.5%, the power supply to the electrical equipment in the refrigerating machinery compartment is cut off and the alarm systems are activated.

(3) The alarm systems 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 be 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 appropriate by the Society.

4.7 Electrical Equipment

4.7.1 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 of 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 **4.6.1-1(2)** activates.

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

4.8 Safety and Protective Equipment

4.8.1 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.) ×2

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

(3) Protective goggles ×2

(4) Eye washer ×1

(5) Boric acid

(6) Emergency electric torch ×2

(7) Electric insulation resistance meter ×1

Chapter 5 REFRIGERATED CHAMBERS

5.1 Construction of Refrigerated Chambers

5.1.1 Materials used for Refrigerated Chambers

Decks, floors and boundary bulkheads of 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 appropriate materials subject to the approval of the Society.

5.1.2 Airtightness of Closing Appliances

Closing appliances such as hatch covers, accessdoors, 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.

5.1.3 Welding and Materials of Steelworks 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.

5.1.4 Coamings of Manholes, etc.

Tank top insulation in way of manholes and bilge hats is to be provided with a liquidtight coaming with a suitable height to prevent seepage into the insulation.

5.1.5 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 watertight 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 steelwork. Airtightness of the bulkheads or decks is to be maintained. Where these pipes pass through deck plating or watertight bulkheads, the fittings and packing of the glands are to be both fireresisting 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 chambers and 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.

5.1.6 Insulating Linings, etc.

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

5.1.7 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.

5.1.8 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 insulation from 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.

5.2 Insulation and Insulation Materials

5.2.1 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.

5.2.2 Protective Coatings

1 Steelworks 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.

5.2.3 Insulation

1 The thickness of insulation over all surfaces and the manner in which it is supported are to be in accordance with the approved specification and plans. The insulation is to be strongly fixed so as not to be loose. Where the insulation is of slab form, the joints are to be butted closely together and staggered. Unavoidable crevices are to be filled with suitable insulating material.

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

5.2.4 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.

5.2.5 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, or the surface of the tank plating is to be coated with an approved oil-proof and oil-tight composition of sufficient thickness, before 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. Furthermore, such air 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.

5.3 Temperature Measuring Arrangements

5.3.1 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 thermometer 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 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.

5.3.2 Electric Thermometers

1 Electric power supply to each instrument in refrigerated chambers is to be fed by a separate 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 chambers are to be accurate to the true temperature within ±0.5℃ in the range of below 0℃, and ±0.3℃ in the range of 0℃ and above.

5.4 Drainage Arrangements

5.4.1 General

1 Drainage arrangements are to be in accordance with the relevant requirements in **13.5, Part D of the Rules for the Survey and Construction of Steel Ships** 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.

5.4.2 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 a liquid sealed trap, and those from lower hold spaces are to be fitted, in addition, with non-return valves.

3 Where the chamber temperature contemplated is 0℃ 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 6 TESTS

6.1 Tests at the Manufacturer's Works

6.1.1 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 a pressure equal to the design pressure.

2 Machinery components, pressure vessels and pressure piping intended for use with brine are to be subjected 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 out with air or suitable inert gases or any inert gas with a small amount of the refrigerant added to it. To implement the survey for the tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve other survey methods which it considers to be appropriate.

6.1.2 Performance Tests

1 Compressors, fans, primary refrigerant or brine pumps and their prime movers are to be tested for their performance. To implement the survey for the tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve other survey methods which it considers to be appropriate.

2 Welded parts in pressure vessels and piping are to be tested in accordance with the relevant requirements in **Chapter 11, Part D of the Rules for the Survey and Construction of Steel Ships**.

3 Electrical equipment is to be tested in accordance with the requirements in **Chapter 2, Part H of the Rules for the Survey and Construction of Steel Ships**.

6.2 Tests during Construction

6.2.1 Leak Tests

1 The primary refrigerant system is to be leak tested after the piping arrangement is completed on board the ship, generally with inert gases or inert gases with a small amount of refrigerant added, to a pressure of 90% of the respective design pressures.

2 The brine system is to be leak tested 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.

6.2.2 Calibration of Thermometers

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

6.2.3 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.

6.2.4 Functional Tests

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

6.2.5 Tests 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-by units is smooth. This test may be carried out in the cooling down stage at the heat balance test specified in **6.2.6**.

6.2.6 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 20℃ 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 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.

6.2.7 Defrosting Tests

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

Chapter 7 LOADING PORT SURVEYS

7.1 General

7.1.1 General

1 At the request of the shipowner or his representative, the Surveyor may carry out Loading Port Surveys on a registered refrigerating installation at a loading port in accordance with the requirements in 7.1.2. On completion of the survey to the satisfaction of the Surveyor, "Certificate on Loading Port Survey" will be issued.

2 A Loading Port Survey may be carried out concurrently with other surveys of the refrigerating installations such as Annual Surveys.

3 If there is no Surveyor to the Society at the loading port(s), the Society will accept the report of a survey, except the case mentioned in -2, held at the loading port by a reliable competent person as considered appropriate by the Society, provided that all requirements of Loading Port Surveys are fulfilled.

7.1.2 Items to be Examined

At the Loading Port Survey, the following items are to be confirmed or examined.

(1) The refrigerating installation is to be examined under working condition to confirm that it operates in good order, and the temperatures at that time in the refrigerated chambers are to be noted.

(2) The Surveyor is to ascertain that there is ample generating capacity available for the ship's essential services and maximum required power to the refrigerating installation, even when one generator is out of use. Where the electric power source is also used as the ship's main power supply, it is to be ascertained that the chamber temperature can be maintained at the specified value with the remaining generators used.

(3) The refrigerated chambers are to be examined in an empty state to ascertain that:

(a) They are clean and free from odour which may adversely affect the cargo to be loaded.

(b) Brine or refrigerant pipe grids, coils of air coolers and connections are free from leakage.

(c) Cargo battens, where fitted to the vertical walls, are in good order.

(d) Cargo gratings or dunnages are available as necessary for the floors or decks.

(e) There is no damage sustained to the insulation or its linings in the refrigerated cargo holds.

(f) All scuppers and bilge suctions for draining the refrigerated cargo holds are in good working order, and water sealed traps are provided.

Contents

GUIDANCE FOR CARGO REFRIGERATING INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 The refrigerants listed below are not to be used as refrigerants.

(1) Methyl chloride (CH_3Cl)

(2) *R*12 (CCl_2F_2)

(3) *R*22 （$CHClF_2$）

(4) *R*502 (*R*22/*R*115 (48.8/51.2 *wt*%) $CHClF_2/CClF_2CF_3$)

(5) *R*13*B*1 (CF_3Br)

(6) Other refrigerants as deemed inappropriate by the Society.

2 The wording "Considered appropriate by the Society" in **1.1.1-5 of the Rules** means to apply **Annex 1.1.1-2** "GUIDANCE FOR CONTROLLED ATMOSPHERE SYSTEMS".

1.1.2 Special Installations

Refrigerating installations of cooling air circulation type using insulated containers instead of refrigerated chambers are to be in accordance with the following **(1)** to **(6)**. In this Guidance, refrigerating machinery includes cooling air circulation fans and their driving motors, air coolers, controls, and piping arrangement up to the place connected to the insulated containers, excluding the insulated containers.

(1) Plans and information to be submitted

In addition to the plans and information specified in **2.2.1-3 of the Rules**, plans indicated in the following **(a)** to **(c)** are to be submitted.

(a) Temperature control system plan of insulated containers.

(b) Outline drawing of the connecting devices and connecting flexible couplings for insulated containers and ventilation ducts.

(c) General arrangement of ventilation ducts and their insulation.

(2) Descriptive notes

When a ship carries insulated containers, the following descriptive note is added to the classification character. "*Equipped for carriage of insulated containers*."

(3) Registration surveys

At a registration survey (limited to Registration Surveys during Construction), the tests listed in the following **(a)** to **(d)** are to be carried out, in addition to the tests mentioned in **2.2 of the Rules**.

(a) Airtight tests for ducts and connections.

After connecting insulated containers to ventilation ducts, airtight tests are to be carried out under the maximum working pressure to ascertain that the leakage from the duct and connection is little.

(b) Functional tests for connecting devices.

The connecting devices for connecting insulated containers to ventilation ducts are to be ascertained that they operate satisfactorily.

(c) Air circulation flow tests

Air circulation flow is to be measured at the exit of each duct connected to insulated containers.

(d) Cooling capacity tests

After insulated containers of sufficient number approved by the Society are connected, cooling capacity tests are to be carried out to ascertain that the cooling capacity of refrigerating machinery and the circulating capacity of cooling air

meet the design specification and they satisfy the requirements in **3.1.2-1 of the Rules**.

(4) Registration maintenance surveys

At an annual survey, functional tests of the connecting devices for insulated containers and ventilation ducts are to be carried out, in addition to the tests specified in **2.3.2 of the Rules**.

(5) Loading port surveys

A loading port survey is to be carried out in accordance with the following items.

(a) The Surveyor carries out a loading port survey on a registered insulated container at the place notified by the applicant in accordance with the requirements in the following **i)** to **v)**, under the condition before loading refrigerated cargoes. On completion of the survey to the satisfaction of the Surveyor, "Certificate on Loading Port Survey" will be issued.

i) The containers are to be clean and in good condition, and free from defects which may adversely affect cargoes to be loaded.

ii) The insulation is to have no damage which may interfere with the function of refrigerated containers.

iii) All drainage, scuppers, and their water sealed traps are to be in good working order.

iv) Temperature sensors are to function normally.

v) The container's door must be closed tightly.

(b) The Surveyor carries out a loading port survey on a registered refrigerating installation including refrigerating machinery and insulated containers in accordance with the requirements in the following **i)** to **vi)**, under the condition that insulated containers on board the ship are connected to ventilation trunks. On completion of the survey to the satisfaction of the Surveyor, "Certificate on Loading Port Survey" will be issued.

i) Insulated containers are to be stowed firmly.

ii) Insulated containers are to have no outer damage.

iii) Refrigerating machinery and fans are to be examined under working condition to ascertain that they operate satisfactorily.

iv) Temperatures in insulated containers are to be recorded. Further, the variations of temperatures within containers during the period from the time when cargoes were loaded in the containers to the time when the containers were stowed on board the ship are to be examined to ascertain that there is no temperature rise beyond the predetermined level.

v) Leakage from the places where ventilation trunks are connected to insulated containers is to be little.

vi) It is to be ascertained that there is ample generating capacity available for the refrigerating installation to keep the insulated containers at the specified temperatures, even when one generator is out of use. Where the electric power source is also used as the ship's main power supply, it is to be ascertained that the remaining generators are capable of supplying the required power for the ship's essential services as well as the refrigerating installation.

(6) Items other than those mentioned above are to be in accordance with the Rules.

Chapter 2 SURVEYS

2.1 General

2.1.2 Registration Surveys and Intervals of Registration Maintenance Surveys

The wording "the Society may approve the survey methods which it considers to be appropriate." in **2.1.2-2(3) of the Rules** means survey methods which the Society considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where a surveyor is in attendance.

2.1.4 Procedure for Tests, Wear and Tear, etc.

With respect to **2.1.4-5 of the Rules**, surveyors are to confirm at periodical surveys that asbestos-free declarations and supporting documents are provided for any replaced or newly installed fittings, equipment, parts, etc. The wording "materials containing asbestos" means that asbestos is present in the product/material above the threshold value stipulated in Appendix 1 of *IMO* resolution *MEPC*.379(80).

2.2 Registration Surveys

2.2.1 Registration Surveys

Surveyors are to confirm the asbestos-free declarations and supporting documents specified in **2.2.1-4 of the Rules**. The wording "materials containing asbestos" means that asbestos is present in the product/material above the threshold value stipulated in Appendix 1 of *IMO* resolution *MEPC*.379(80).

2.2.2 Registration Surveys Not Built under the Survey

The wording "where the Surveyor approves it" specified in **2.2.2-2 of the Rules** means that there are reasonable records or valid certificates to the satisfaction of the Surveyor.

2.3 Registration Maintenance Surveys

2.3.1 Special Surveys

1 The wording "the interval of opening up" specified in **2.3.1-1(8) of the Rules** means the interval of 25,000 *hours* of operation.

2 The wording "Operation tests" specified to in **2.3.1-1(18) of the Rules** means the confirmation of the effectiveness of each unit under operating condition. At this time, leak tests of refrigerant are to be carried out. When necessary, the concentration of brine is to be measured.

3 "Continuous Surveys" specified in **2.1.3-5 of the Rules** is conform to the following requirements:

(1) Submission of application for Continuous Survey system.

When the shipowner or his representative desires to adopt a Continuous Survey system, he is to submit an application form (**Form-CMS-1E**) to the Society for approval on application for that system.

(2) Plans for Undergoing Continuous Surveys

The owner of a ship to which continuous survey system is applied is to prepare "Plan for Undergoing Continuous Surveys on Cargo Refrigerating Installations" or "Plan for Maintaining Cargo Refrigerating Installations," taking into account items listed in the following **(a)** to **(d)**, and carry it on board the ship so that it can be presented to the Surveyor whenever he requires it.

(a) All items to be covered by continuous surveys are to be included in the plan.

(b) Inspection interval of each survey item is not to exceed five years.

(c) Inspection of each compressor is to be carried out alternately and with the same interval, as far as possible.

(d) Inspection of each pump is to be carried out alternately and with the same interval, as far as possible, by its use.

(3) Items to be covered by Continuous Surveys

At continuous surveys, open-up inspection and pressure tests are to be carried out on the following machinery and equipment.

(a) Compressors

(b) Condenser cooling water pumps
(c) Primary refrigerant pumps
(d) Brine pumps
(e) Condensers
(f) Evaporators
(g) Others to be considered appropriate by the Society

(4) Confirmatory Surveys

On the items listed in **(a)** to **(d)** of **(3)** above, confirmatory surveys may be carried out in accordance with the procedures specified in **B9.1.2-6 of the Guidance for the Survey and Construction of Steel Ships**. For compressors, at least one unit of them is to be subject to open-up inspection during the period of one cycle of continuous surveys.

(5) Cancellation of Continuous Survey System

(a) Where the shipowner or his representative requests the cancellation of applying the continuous survey system, the subsequent surveys are to be in accordance with the following **i)** and **ii)**.
  i) Where there are machinery and equipment of which their inspection intervals will exceed five years before the next special survey, they are to be inspected within five years from the dates on which the previous surveys were carried out.
  ii) At the next special survey, inspection is to be made on all items to be required at a special survey.

(b) Where continuous surveys are not carried out in accordance with this Guidance, the application of continuous survey system may be cancelled.

2.3.3 Occasional Surveys

The wording “the Society may approve the survey methods which it considers to be appropriate.” in **2.3.3 of the Rules** means survey methods which the Society considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where a surveyor is in attendance.

Chapter 3 REFRIGERATING MACHINERY

3.1 General

3.1.2 Capacity and Number of Refrigerating Machinery

Where contact freezers are installed, their cooling capacity is to be added to the capacity specified in **3.1.2-2 of the Rules**.

3.1.3 Materials and Welding

The wording "to be approved by the Society" specified to in **3.1.3-6 of the Rules** means that approval is to be made in accordance with the requirements in **Chapter 2** or **6**, **Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

3.2 Construction, etc. of Refrigerating Machinery

3.2.1 Refrigerant Compressors

"Automatic cut off devices" specified in **3.2.1-3 of the Rules** includes flow switches.

3.2.3 Pressure Vessels Exposed to the Refrigerant Pressure

1 Vessels supplying refrigerant for refrigerating machinery may be made of materials passing the inspection based on the suitable code.

2 Other pressure vessels include contact freezers.

3.3 Cooling Appliances in Refrigerated Chambers

3.3.5 Temperature Difference

Temperature difference between the refrigerated chamber and the refrigerant is, as a rule, to be within 5℃ for fruit, and 10℃ for frozen meat.

Chapter 4 SPECIAL REQUIREMENTS FOR REFRIGERATING MACHINERY USING AMMONIA AS REFRIGERANT

4.5 Gas Expulsion System

4.5.1 General

"The quantity of sprinkled water is to be such that the leaked gas can be satisfactorily absorbed." mentioned in requirement **4.5.3(2)(a) of the Rules** refers to taking the standard value of water quantity sprayed, as 0.26*A* (*l/min*.) or 160 (*l/min*.), whichever is greater. However, if the calculation is carried out based on the quantity of water sprayed from each nozzle at the used pressure, then this requirement on does not apply. *A* is the total volume (*l*) of the receiver.

4.5.2 Ventilation System

The ventilation fan which is of "a construction such that sparks" specified in **4.5.2-1(5) of the Rules** mean those ventilation fans complying with the requirements of **R4.5.4-1(2), of the Guidance for the Survey and Construction of Steel Ships**. For the purpose of this requirement, protection screens of not more than 13*mm* square mesh are to be fitted in the inlet and outlet ventilation openings of the ducts fitted with such fans on the open deck.

4.7 Electrical Equipment

4.7.1 General

The wording "certified safe types for use in the flammable atmosphere concerned" in **4.7.1-1 of the Rules** means electrical equipment having intrinsically safe, flame-proof or pressurized construction certified as Apparatus Group *II*A and Temperature Class *T*1 or higher as specified in *IEC* 60079 or Explosion Class *d*1 and Ignition Group *G*1 or higher as specified in the Recommended Practices for Explosion-Protected Electrical Installations in General Industries (NIIS-TR-NO.39 (2006)) issued by National Institute of Industrial Safety in Japan, or equivalent thereto.

Chapter 6 TESTS

6.1 Tests at the Manufacturer's Works

6.1.1 Pressure Tests and Leak Tests

The wording "the Society may approve other survey methods which it considers to be appropriate" in **6.1.1-3 of the Rules** means survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where the Surveyor is in attendance.

6.1.2 Performance Tests

The wording "the Society may approve other survey methods which it considers to be appropriate" in **6.1.2-1 of the Rules** means survey methods which it considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where the Surveyor is in attendance.

6.2 Tests during Construction

6.2.6 Heat Balance Tests

1 "Reasonable redundancy" specified in **6.2.6(3) of the Rules** is to be 20% or so.

2 Mean coefficients of overall heat transmission may be calculated according to **Annex 6.2.6-2** "GUIDANCE FOR THE HEAT RATING CALCULATION OF REFRIGERATING INSTALLATIONS".

3 Items to be measured during heat balance tests are the following **(1)** and **(2)**.

(1) Items to be measured for calculating coefficients of overall heat transmission.

(a) Temperatures in refrigerated chambers.

(b) Ambient temperatures around outside insulation walls. (Atmospheric temperature, sea water temperature, machinery space temperature, adjacent uninsulated compartment temperature, temperature in double bottoms)

(c) Fore and aft draughts

(d) Power input of driving motors for air circulating fans.

(e) Power input of driving motors for brine pumps and refrigerant pumps in refrigerated chambers.

(2) Items to be measured for calculating refrigerating capacity.

(a) Output and revolutions of compressor driving motors.

(b) Temperature and pressure of compressor intake gas.

(c) Temperature and pressure of compressor outlet gas.

(d) Temperature and pressure of refrigerant in condenser.

(e) Temperature and pressure of liquid refrigerant before the expansion valve.

(f) In the case of brine system, intake and outlet brine temperatures of brine coolers.

(g) Evaporating temperature of refrigerant at the evaporator.

4 Of the items to be measured listed in **-3** above, temperatures in refrigerated chambers and adjacent un-refrigerated compartments, etc. are to be measured in the ways mentioned below.

(1) The temperatures in a refrigerated chamber are to be measured with detecting elements to the number of 1/3 of the minimum requirements specified for each chamber or 2 whichever is the greater, arranged at a height about 1/2 of the height of the chamber and on the centre line of the chamber at equal distances. In places where the air flow is great, wind screens suitable for detecting temperature are to be provided. Notwithstanding the above, temperature measuring arrangements and temperature recording arrangements which have been installed may be used for measuring.

(2) Atmospheric temperature is to be measured at both sides of the middle of the ship. (Temperature may be arranged so that they can be read easily from on the deck, but they are to be at least 500 *mm* apart from the hull.)

(3) Seawater temperature is to be measured at both sides of the middle of the ship.

(4) Temperatures in adjacent un-refrigerated compartments are to be measured in accordance with the following **(a)** to **(c)**.

(a) Machinery space: On the side adjoining the refrigerating machinery compartment, the temperature in the refrigerating machinery compartment is to be measured at one point or more, and the representing temperature of the machinery space is to be measured at one point. (These measuring points are to be at least 300 *mm* apart from the bulkhead.)
On the side opposite to the above, the representing temperature of the machinery space is to be measured at one point. For wind screens, the same as in **(1)** above.

(b) Other un-refrigerated compartment: Temperature is to be measured at one point at least 300 *mm* apart from the bulkhead surface and near the centre of the bulkhead.

(c) Double bottom: Temperature is to be measured at one point in each hold.

Annex 1.1.1-2 GUIDANCE FOR CONTROLLED ATMOSPHERE SYSTEMS

1.1 General Requirements

1.1.1 General

1 Application

(1) The Guidance applies to the survey and construction of the controlled atmosphere systems (hereinafter referred to as the "**CA** system") which may be considered under the provision of **1.1.1-5 of the Rules for Cargo Refrigerating Installations** (hereinafter referred to as "the Rules") and is to be registered under **Chapter 3 of the Regulations for the Classification and Registry of Ships**.

(2) The Guidance applies to **CA** systems using Nitrogen as a sealing gas. For **CA** system using other gases, the respective requirements will be determined as appropriate.

2 Notice in Application

The Guidance specifies the minimum requirements for the protection of human beings and hull, and the standard for the construction and installation for the protection of cargoes during its transportation under a normal operating and running condition of the **CA** system. Attention is to be paid to handling of the **CA** system regardless of the consequence that it has been designed, installed and surveyed in accordance with these requirements.

3 Installation Characters

The cargo refrigerating installation equipped with the **CA** system, after having been surveyed by the Surveyors according to the Guidance and found to be satisfactory for registration, will be assigned the following installation character;

RMC* **・CA** or **RMC ・CA**

4 Installation Notations

The installation notation will be affixed to the installation character for the **CA** system as follows:

Where the **CA** system is equipped with a fixed Nitrogen generator;

e.g. **RMC*** (-30℃/32℃ *and Equipped for Cariage of Fruit*) **・CA** (*Equipped with Fixed* N_2 *Generator*)

1.1.2 Definitions

The terms used in the Guidance are defined as follows:

(1) "**CA** zone" means air-tight cargo chambers have a controlled atmosphere.

(2) "Dangerous zone" means **CA** zones and enclosed zones which are adjacent to **CA** zones.

(3) "Gas" means a mixture of Nitrogen, Carbon dioxide and Oxygen to be controlled in a **CA** zone.

1.2 Surveys

1.2.1 Registration Surveys

1 Drawings and Documents

Triplicate, the following drawings and documents, are to be submitted to the Society, for registration of the respective **CA** system;

(1) Drawings (with materials, sizes, types, design pressures and design temperatures, etc. of pipes, valves, etc.)

(a) General arrangements of the **CA** zones, dangerous zones and **CA** system.

(b) Detailed plans of sealing devices for all openings of hatches, doors, ventilation ducts, scupper pipes, bilge pipes, vent pipes, etc., and deck and bulkhead penetrations of all pipes, electrical cables, ducts, etc., in order to confirm the air-tightness of **CA** zones.

(c) Piping diagrams of pressure measuring and gas sampling systems in **CA** zones

(d) Details and arrangements of gas pressure and vacuum relief valves (*P.V.* valves)

(e) Details and arrangements of ventilation system for **CA** zones, nitrogen generating room and enclosed zones which are adjacent to **CA** zones

(f) Particulars of nitrogen generating equipment and nitrogen supply piping diagrams

(g) Wiring diagrams of the **CA** system
(h) Line diagrams of all control circuits
(i) Control diagrams of all valves and dampers in **CA** zones
(j) Plans of audible and visual warning systems including location of master station and warning devices
(k) Other drawings as considered necessary by the Society

(2) Documents
(a) Specifications of the **CA** system
(b) Electrical power consumption tables
(c) List of monitored, control and alarm points
(d) Details of fixed or portable oxygen level sensors
(e) Computer systems, if fitted
(f) Operation Manual
(g) Details of personnel safety and resuscitation equipment
(h) Details of humidification systems, if fitted
(i) Details of testing programme for the **CA** system
(j) Other documents as considered necessary by the Society

2 Initial Tests and Surveys for Registration

The tests and surveys for registration are as follows;

(1) Air-tightness of each **CA** zone is to be verified by test. For the test, after all openings are closed, the time for the water head from 25 *mm* to 10 *mm* in each **CA** zone is to be not less than 10 *minutes*.
(2) Fixed nitrogen generating equipment is to be tested under working conditions after installation on board.
(3) *P.V.* valves fitted to each **CA** zone are to be tested in operation.
(4) Gas freeing systems are to be demonstrated after installation on board.
(5) Control, alarm and monitoring systems required under the requirements of **1.5**, are to be demonstrated after installation on board.
(6) Portable measuring devices are to be tested for their function and accuracy. Any test records of their makers may be acceptable for their performance tests.
(7) Safety devices, locking devices and warning notices, etc. required according to the requirements of the Guidance, are to be inspected to ensure the correct number and effectiveness of their arrangements.

1.2.2 Registration Maintenance Surveys

1 Annual Surveys

At an Annual Survey, the followings are to be carried out by the Surveyors;

(1) Control, alarm and monitoring devices of the **CA** system are to be generally examined.
(2) Running records of the **CA** system are to be examined to ensure correct functioning.
(3) Voyage logs are to be examined to ensure the air-tightness of each **CA** zone.
(4) Fixed nitrogen generating equipment is to be generally examined or to be tested under working conditions where considered necessary by the Surveyors.

2 Special Surveys

At a Special Survey, the following **(1)** to **(3)**, in addition to the requirements of **1.2.2-1**, are to be carried out by the Surveyors;

(1) Hatches, access doors and ventilation ducts, and deck and bulkhead penetrations of all pipes and electric cables in **CA** zones, are to be examined for their air-tightness.
(2) *P.V.* valves in each **CA** zone are to be tested for correct.
(3) Control, alarm and monitoring devices of the **CA** system are to be demonstrated.

1.3 Refrigerated Chambers

1.3.1 CA Zones

1 Air-tightness of CA Zones

(1) Each **CA** zone is to be made as air-tight as possible.

(2) Deck and bulkhead penetrations of all pipes, electrical cables, trunks, etc. in **CA** zones are to be suitably sealed and made air-tight.

(3) Adequate closing appliances, such as covers, doors and manholes are to be provided for the openings in cargo hatches, entrances, etc. of **CA** zones in order to keep the air-tightness.

2 Personnel Protection

(1) Closing appliances of hatches, entrances, ventilators, etc. of **CA** zones are to be so constructed as to be capable of preventing from easy opening due to impact force or mis-handling under the controlled atmosphere. Hatch covers and doors at entrances are to be capable of being locked. Warning notices are to be posted at all openings to prevent inadvertent opening under the controlled atmosphere.

(2) Each **CA** zone is to be provided with warning alarm which will be given before injection of nitrogen into the **CA** zone in such a way that the inlet valve cannot be opened unless the alarm signal has been given.

1.3.2 Protection of CA Zones

Pressure and Vacuum Relief Valves (*P.V.* valves)

(1) *P.V.* valves are to be provided to limit abnormal positive or negative pressure in each **CA** zone.

(2) Outlets of the valves are to be located as high as possible above the upper deck to obtain the maximum disposal of nitrogen, but in no case less than 2 *m* above the deck and 5 *m* away from air inlets and openings in accommodation spaces, service spaces and machinery spaces.

1.3.3 Gas Freeing

Gas Freeing Systems

(1) Gas freeing systems are to be provided to discharge the gas in order to increase oxygen content to 21% in each **CA** zone.

(2) Outlets of the gas freeing systems are to be located in accordance with the requirements of **1.3.2(2)**.

(3) Warning notices are to be posted at the outlets.

1.3.4 Enclosed Spaces adjacent to CA Zones

General

(1) In general, **CA** zones are not to be contiguous with the boundaries of accommodation spaces.

(2) For enclosed spaces except water tanks and oil tanks adjacent to **CA** zones, mechanical ventilators operable from outside the spaces are to be provided.

1.4 Nitrogen Generating Equipment

1.4.1 General

1 Applications

Nitrogen generators or other equivalent equipment as well as pipes, valves and fittings are to be designed and installed according to the requirements in this Chapter.

2 Capacity

Nitrogen generators are to have sufficient capacity to maintain the specified oxygen level in all **CA** zones. Where fixed nitrogen generators are installed, the arrangements are to be such that a single fault will not cause a loss of gas supply.

3 Electrical Equipment and Power Supply

Electrical equipment for nitrogen generators is to be designed and installed according to the requirements of **Part H of the Rules for the Survey and Construction of Steel Ships**. The electric power supply to the **CA** system is to be capable of maintaining the specified oxygen level of the **CA** zones without interfering with the supply of power to the essential services of the ship, in case any one generator should fail.

4 Construction and Materials

Construction and materials of machinery components, pressure vessels, pipes, valves and fittings used for nitrogen generators are to comply with the requirements of **Chapter 10**, **11**, **12** and **13, Part D of the Rules for the Survey and Construction of Steel Ships**.

1.4.2 Installation of Nitrogen Generators

1 Fixed Nitrogen Generators

Fixed nitrogen generators are to be installed in a dedicated room, air-tight from the adjacent spaces, having access only from the open decks, but may be installed in machinery spaces, in cases where considered appropriate by the Society.

2 Portable Nitrogen Generators

Each container, in which a nitrogen generator is fitted, is to be properly secured to the hall construction and designed to be suitable for the service condition.

3 Nitrogen Supply

(1) Adequate means to vent the excess nitrogen and generated oxygen from nitrogen generators to the atmosphere are to be provided. All vents are to be led to a safe location on the open deck.

(2) Nitrogen supply piping systems (including sample pipings and circulating pipings) are not to pass through accommodation spaces, service spaces and control stations. The piping may pass through void spaces where a double wall piping system is adopted.

4 Relief Valves

Each air compressor for nitrogen generators is to be provided with relief valves at the discharge side.

5 Ventilation of Nitrogen Generator Room

Nitrogen generator room is to be fitted with an exhaust mechanical ventilation system. The ventilation system is to have a capacity of more than 10 air changes per hour based on the total volume of the room, and to be capable of being controlled from outside the room.

1.5 Control, Alarm and Monitoring Systems

1.5.1 General

1 Control, alarm, monitoring and safety devices are to be provided for personnel safety and the efficient operation of the **CA** system.

2 Alarm systems are to be arranged to give visual and audible alarms at the monitoring station.

3 Alarm and monitoring systems are to have self-monitoring function and to be arranged to give visual and audible alarms in case of failure of the systems themselves.

4 Control systems, alarm systems and safety systems are to be designed in accordance with the requirements of **18.2, Part D of the Rules for the Survey and Construction of Steel Ships**.

1.5.2 Nitrogen Supply Piping

Nitrogen supply piping is to be provided with alarm devices in the supply main which will operate in the event of the high oxygen content conditions.

1.5.3 CA Zones

1 Gas Analysers

Oxygen and carbon dioxide analysers with alarm devices are to be provided for controlling the oxygen content and carbon dioxide content in each **CA** zone, and are to be in accordance with the following requirements.

(1) At least two sampling points are to be provided at each **CA** zone.

(2) Gas analysers are to be located at well ventilated areas, and the extracted gas for sampling is to be blown off to a safety space after analysis.

(3) The sampling frequency is to be at least once per hour.

(4) Gas analysers are to be capable of periodic and safe calibration.

2 Alarm Devices

Each **CA** zone is to be provided with alarm devices which will operate in the event of the following abnormal conditions.

(1) High or low level oxygen content

(2) High level carbon dioxide content

(3) Abnormal high pressure

1.5.4 Fixed Nitrogen Gas Generators

1 Safety Devices

Safety devices are to be provided at each air compressor for fixed nitrogen generators to stop the compressors automatically in the

event of the following abnormal conditions of the compressor.

(1) Loss of lubricating oil pressure

(2) High temperature of discharge air

1.5.5 Alarm and Monitoring Devices for Personnel Safety

Fixed oxygen alarm and monitoring devices are to be provided at the following areas in order to monitor the oxygen content and to alarm at each place in the event of low level oxygen content.

(1) Enclosed spaces adjacent to **CA** zones. However, spaces where there are no cables, pipes, trunks, or ducts penetrating into **CA** zones and crew members do not normally work may be exempted.

(2) Fixed nitrogen gas generator room

1.6 Safety Equipment

1.6.1 General

1 Communication Equipment

(1) A means of two-way communication is to be provided between **CA** zones and the nitrogen release control station.

(2) In cases where portable radiotelephone apparatus is adopted to comply with the requirements specified in **(1)**, at least three sets of the apparatus are to be provided on board. Additional portable radiotelephone apparatus may be requested depending on the operation method. The portable radiotelephone apparatus is to be independent of the apparatus required by the *SOLAS* Convention III/6.2.1.

2 Portable Oxygen Measuring Instruments

At least ten portable oxygen measuring instruments with alarm are to be provided on board for the safe entrance to dangerous zone.

3 Medical First-aid Equipment

Medical first-aid equipment including oxygen resuscitation equipment is to be provided on board.

Annex 6.2.6-2 GUIDANCE FOR THE HEAT RATING CALCULATION OF REFRIGERATING INSTALLATIONS

1.1 Calculation Procedure for Mean Coefficients of Overall Heat Transmission (K_{m1}) for Designing the Thermal Insulation Systems for the Entire Refrigerated Cargo Holds

(Refer to **Form RMC1-1**, **RMC1-2**, **RMC1-3** and **RMC1-4**)

$$K_{m1} = \frac{Q_{1D}}{\sum A_{Di} \cdot \Delta T_{Di}} \ (W/m^2℃) \qquad (1)$$

where:

Q_{1D}:Quantity of heat transmitted through insulated walls from surroundings of the refrigerated cargo hold into inside , in accordance with equation (2)

$$Q_{1D} = \sum K_i \cdot A_{Di} \cdot \Delta T_{Di} + \sum H_i \cdot L_{Di} \cdot \Delta T_{Di} \ (W) \qquad (2)$$

$\sum K_i \cdot A_{Di} \cdot \Delta T_{Di}$: Quantity of heat transmitted via the surfaces of insulated walls of the refrigerated cargo hold into inside (W)

$\sum H_i \cdot L_{Di} \cdot \Delta T_{Di}$: Quantity of heat transmitted through deck lines from surrounding of the refrigerated cargo hold into inside (W)

K_i : Coefficient of overall heat transmission of each heat insulated wall (W/m^2 ℃) (*See Supplement* 1)

A_{Di} : External surface area of each heat insulated wall (m^2)

ΔT_{Di}: Design temperature difference across each heat insulated wall (℃) (*See Supplement* 2)

H_i : Coefficient of heat entry of each deck line and bulkhead line (W/m ℃) (*See Supplement* 3)

L_{Di} : Length of each deck line and bulkhead line (m)

Note: For determiningQ_{1D}, the areas of insulated walls having the compatible structural setup and the conditions of heat entry on the exterior surface of the insulated wall (A_{Di}) are to be summed up, and the results thus obtained are to be multiplied by the temperature difference across the insulated wall (ΔT_{Di}) and the coefficient of overall heat transmission (K_i) of the insulated wall. It is the routine practice to calculate by multiplying the temperature differences at such areas as upper deck which is exposed directly to sun beams, side shell on and below the water line, bulkhead forming the machinery space, bulkhead facing non-insulated compartment, tank top including double bottom and bilge strake, by the coefficient of overall heat transmission. Furthermore, the quantities of heat entry through deck lines and bulkhead lines are added up to the above. Where deck girders are involved, the coefficient of overall heat transmission (K_i) of the insulated wall, in question, is to be multiplied by a specified factor.

$\sum A_{Di} \cdot \Delta T_{Di}$: Total sum of the products of the exterior surface areas of the insulated walls and design temperature difference (m^2℃)

Note: The areas of insulated walls having the compatible structural setup and the temperature difference across the insulated wall and the same heat entry conditions on the exterior surface of the insulated wall are to be summed up, and the results thus obtained are to be multiplied by the temperature difference across the insulated wall. It is the routine practice to calculate by multiplying the temperature differences at such areas as upper deck which is exposed directly to sun beams, side shell on and below the water line, bulkhead forming the machinery space, bulkhead facing non-insulated compartment, tank top including double bottom and bilge strake, by respective areas of these.

(1) Method for calculating coefficients of overall heat transmission K_i (The calculated value of K_i is to be entered in **Form RMC1-3**.)

$$K_i = \eta \cdot (1 + \omega) \cdot \frac{1}{\frac{1}{\alpha_1} + \sum \frac{d_i}{\lambda_i} + \frac{1}{\alpha_2}} \cdot \xi (W/m^{2\circ}C) \qquad (3)$$

where:

η:Frame factor, to be determined from equation (4) or **Fig. 1**

$$\eta = \frac{D}{S}\left[\frac{F}{D-h} + \frac{S-F-1.7h}{D} + 3\log_{10}\left(\frac{D+0.6h}{D-h}\right)\right] \quad (4)$$

where:

S : Frame space (mm)

F : Frame face width (mm)

D : Thickness of heat insulation (mm)

h : Length of the frame (mm)

ω: Coefficient of sleeper, to be determined from either equation (5), (6) or **Table 1**.

$$\omega = \frac{\frac{2}{\pi}(\alpha-1)\ln\left(1+\frac{\frac{\pi}{2}C}{a}\right)}{\frac{F}{a}+\frac{4}{\pi}\ln\left(1+\frac{h}{a}\right)+\frac{S-\left(F+\frac{4}{\pi}h\right)}{a+h}} \quad (5)$$

where:

$a = D - h$

C : Width of sleeper (mm)

D : Thickness of heat insulation (mm)

h : Length of frame protruding into heat insulation (mm)

S : Frame space (mm)

$\alpha = \frac{\lambda_W}{\lambda}$

λ_w : Coefficient of thermal conductivity of sleeper (W/m ℃)

λ : Coefficient of thermal conductivity of heat insulation material (W/m ℃)

$$\omega = 0.27 \times \frac{0.041}{\lambda} \quad (6)$$

α_1 : Heat transfer coefficient of the interior surface of refrigerated cargo hold, to be as follows;

Grid coil cooling system: α_1= 8 (W/m^2 ℃)

Air circulation system: α_1= 23 (W/m^2 ℃)

α_2 : Heat transfer coefficient of the exterior surface of refrigerated cargo hold = 35 (W/m^2 ℃)

λ_i : Coefficient of thermal conductivity of heat insulation material, to be in accordance with **Table 2**.

ξ : Coefficient on workmanship = 1.2~1.3

(2) Procedure to determine temperature difference ΔT_{Di}across insulated walls (The calculated value of ΔT_{Di} is to be entered in **Form RMC1-4**.)

$$\Delta T_{Di} = T_{Da} - T_{Dc} \quad (7)$$

where:

T_{Da} : Standard design temperature as per **Table 3**

T_{Dc} : Design inside temperature of refrigerated cargo hold (℃)

(3) An example of calculation of heat immersion rate H_i to deck lines and bulkhead lines (The calculated value of K_i is to be entered in **Form RMC1-3**.)

$$H_i = \frac{\lambda t}{L+\left(\frac{\lambda t}{K_1+K_2}\right)^{1/2}} \quad (8)$$

where:

H_i : Quantity of heat entry per 1 m of deck line (W/m ℃)

λ : Coefficient of thermal conductivity of steel (W/m ℃)

t : Effective thickness of deck plate (m)

$= t_0 + \frac{A}{S}$

where:

t_0 : Thickness of steel plate (m)

A : Sectional area of beam (m^2)

S : Beam span (m)

K_1 : Coefficient of overall heat transmission of deck surface (W/m^2 ℃)

K_2 : Coefficient of overall heat transmission of under deck surface (W/m^2 ℃)

L : Distance from ship side to the innermost hull heat insulation (m)

Fig. 1

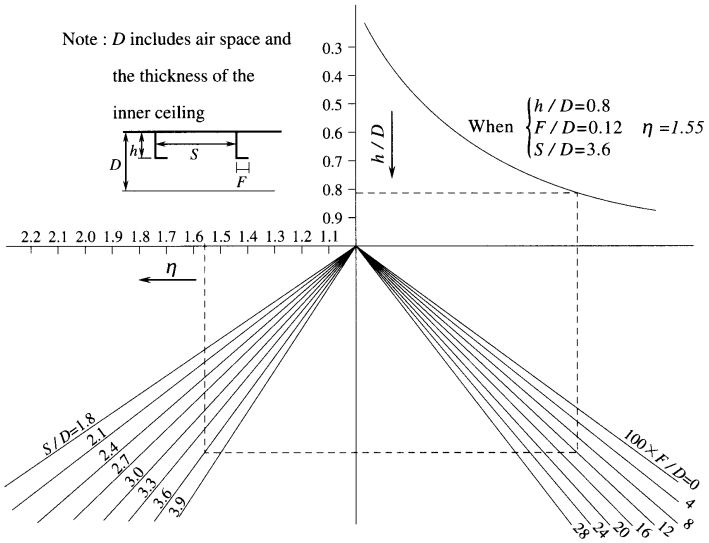


Fig. 2

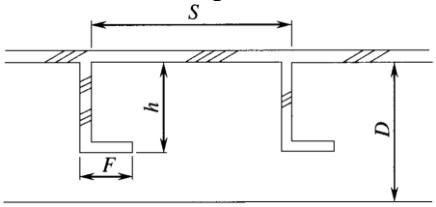


Fig. 3

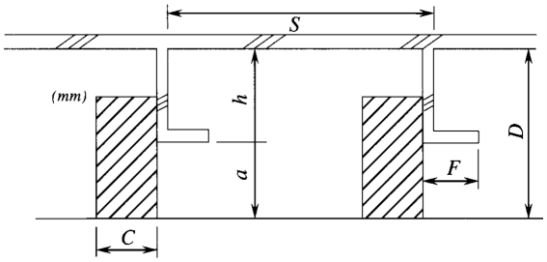


Fig. 4

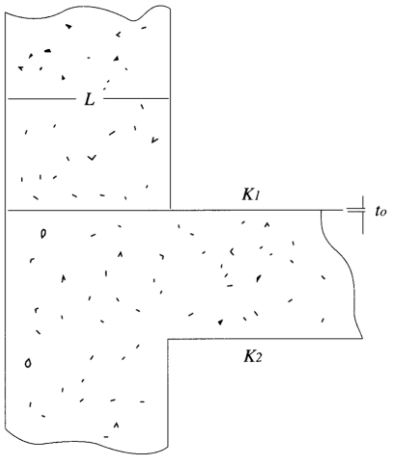
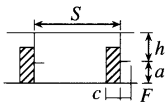
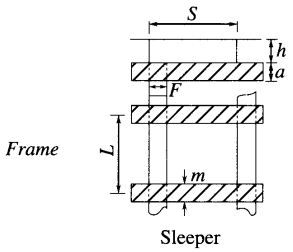
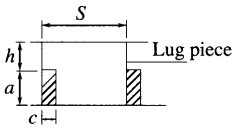
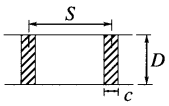


Table 1 Approximation Procedure for ω

Sleeper	Approximation		
	ω	$\frac{h}{a+h}$	A
	$A\times\frac{\frac{0.106}{\lambda}-1}{2.03}$	0.5 0.6 0.7 0.8	0.173 0.190 0.210 0.235
 Frame Sleeper	$A\times\frac{0.035}{\lambda}$	0.5 0.6 0.7 0.8	0.058 0.058 0.058 0.080
	$A\times\frac{0.035}{\lambda}$	0.5 0.6 0.7 0.8	0.050 0.070 0.110 0.140
	$0.128\times\frac{\frac{0.106}{\lambda}-1}{2.03}$	—	—

Thickness of heat insulation: $D = 150\sim300\ mm$
Frame space: $S = 800\ mm$
Coefficient of thermal conductivity of sleepers: $\lambda\omega = 0.106\ W/m°C$ (In case of Pine)
Width of sleeper: $C = 50\ mm$
Coefficient of thermal conductivity: $\lambda = (W/m°C)$

Table 2 Thermal Conductivity Coefficients of Various Insulation Materials (W/m℃)

Material		Mean temp. (℃)		
		-20	0	20
Glass wool	No.2 (24K)	0.034	0.037	0.041
	No.2 (32K)	0.033	0.036	0.040
Foam polystyrene	No.1 (30K)	0.034	0.035	0.037
	No.2 (25K)	0.034	0.036	0.038
	No.3 (20K)	0.036	0.038	0.041
Rock wool	No.1 (100K)	0.038	0.041	0.044
Urethane foam	No.4 (30K)	0.026	0.023	0.024
Wood		0.17		
Steel plate		58		

Table 3 Standard Design Temperature(℃)

Atmospheric temperature ℃	35
Sea water temperature ℃	32
Surface temperature of upper deck ℃	60
Surface temperature of side shell ℃(above water)	50
Inside temperature of engine room ℃	45
Collision bulkhead temperature ℃	40
Double bottom temperature ℃	32
Inside temperature of accommodation space ℃	30*
Indoor temperature in on-deck store ℃	40

Note:

Asterisked figure shows the temperature when air conditioned

1.2 Method of Calculation for the Allowable Limit of Mean Coefficient of Overall Heat Transmission (K_{max}) of the Insulation System for the Entire Refrigerated Cargo Hold during Cold Storage

(Refer to **Form RMC1**)

$$K_{max} = \frac{N_1 Q_{Dc} - \sum Q_{Di}}{\sum A_{Di} \cdot \Delta T_{Di}} (W/m^2 \cdot ^\circ C) \qquad (9)$$

where:

$N_1 Q_{Dc}$: Sum of refrigerating capacity during cold storage (W)

N_1 : Number of refrigerating units during cold storage (excluding the number of stand-by refrigerating machines)

Q_{Dc} : Refrigerating capacity of one refrigerating unit (W) (the standard refrigerating capacity under cold storage when the degree of super cooling of refrigerant is 5℃, the superheated temperature of suction vapour at compressor inlet is 0℃, the condensing temperature is 40℃, and the evaporating temperature is assumed to be the temperature during cold storage)

$\sum Q_{Di}$: Total sum of heat loads in the refrigerated cargo hold (W) (the total design heat load, including the thermal load of brine pumps of canned type, to be handled by the cooling system excluding the heat that infiltrates through the heat insulated walls from the surrounding space of the refrigerated cargo hold.)

Q_{D1} : Heat emission in the refrigerated cargo hold, to be in accordance with the equation (10) (the quantity of heat discharged in the refrigerated cargo hold by fan motors in the case of an air circulation system)

$$Q_{D1} = n \times P \times 1000 \times 1/\eta_m \times \varepsilon/24 \ (W) \qquad (10)$$

n : Number of motors in service

P : Output of motors in service (kW) (to be in accordance with the performance curves prepared by the manufacturer of fans)

η_m : Efficiency of motor

ε: Mean service hours of a motor per day (h)

Q_{D2} : Heat emission of electric lamps in the refrigerated cargo hold, to be in accordance with the equation (11)

$$Q_{D2} = n \times P \times 1000 \times \varepsilon/24 \ \ (W) \qquad (11)$$

n: Number of electric lamps in service

P: Rated power consumption per lamp (kW)

ε : Mean service hours of a electric lamp a day (h)

Q_{D3} : Heat emission by fruits and vegetables, to be in accordance with the equation (12) (This applies to special carries of fruits)

$$Q_{D3} = Q \times V \times C \ \ (W) \qquad (12)$$

Q : Heat of respiration of fruits (W/t)

V : Volume of the refrigerated cargo hold (m^3)

C: Stowage factor (t/m^3)

Q_{D4} : Heat entry associated with the fresh air intaking for fruits, to be in accordance with the equation (13) (This applies to special carries of fruits)

$$Q_{D4} = \frac{a}{3600} \times V \times \gamma \times (i_{a1} - i_{a2}) \ \ (W) \qquad (13)$$

a: Number of air changes ($times/h$)

V : Volume of the refrigerated cargo hold (m^3)

γ: Density of air in the refrigerated cargo hold (kg/m^3)

i_{a1}: Enthalpy of atmospheric air (J/kg)

i_{a2}: Enthalpy of air in the refrigerated cargo hold (J/kg)

Q_{D5} : Other heat to be removed (W)

$\sum A_{Di} \cdot \Delta T_{Di}$: The same as those symbols and explanatory notes for Equation **(1)**.

1.3 Method for Calculating Mean Coefficient of Overall Heat Transmission (K_{m2}) Inferred from the Results of Measurements by Heat Balance Tests

(Refer to **Form RMC2**)

$$K_{m2} = \frac{N_2 Q_{TC} - \sum Q_{Ti}}{\sum A_{Ti} \cdot \Delta T_{Ti}} \ (W/m^2{}^\circ\mathrm{C}) \qquad (14)$$

where:

$N_2 Q_{TC}$: Sum of refrigerating capacity at the time of heat balance test (W)

N_2 : Number of refrigerating units in service

Q_{TC} : Refrigerating capacity of one refrigerating unit, as a rule, to be obtained by the equation (15) utilizing the performance curves included in the results of shop tests of the refrigerating unit:

$$Q_{TC} = Q_{TCD} \times \alpha_1 \times \alpha_2 \times \alpha_3 \times \alpha_4 \ \ (W) \qquad (15)$$

where:

Q_{TCD}: Refrigerating capacity obtained from the performance curves under the conditions at the time of heat balance tests (W)

α_1: Correction factor for condensing temperature of liquid refrigerant

α_2: Correction factor for super cooling of liquid refrigerant

α_3: Correction factor for super heating of vapour refrigerant

α_4: Correction factor for sub-cooling of liquid refrigerant

These corrections may be substituted by those determined from numerical tables.

Remarks: The saturation temperature of refrigerant at the compressor discharge pressure may be used for the condensing temperature of refrigerant, and the saturation temperature of refrigerant at the compressor suction pressure for the evaporation temperature of refrigerant. In the case of a brine system, the brine temperatures may be used. It is necessary to use instruments with a high accuracy.

Calculations of Q_{TC} may be done using **-1(a)** to **(c)**.

$\sum Q_{Ti}$: Sum of thermal loads in the refrigerated cargo hold at the time of heat balance tests (W) (including the thermal load of brine pumps of the canned type)

Remarks: Thermal load measurements at the time of tests are, as a rule, to be actual measurements.

Q_{T1}: Heat emission from in-hold air circulation fans, to be in accordance with the equation (16).

$$Q_{T1} = n \times P \times 1000 \ (W) \qquad (16)$$

n : Number of fans lighted at the time of tests

P : Measured value of power input (kW)

Q_{T2}: Heat emission from lamps, to be in accordance with the equation (17)

$$Q_{T2} = n \times P \times 1000 \ (W) \qquad (17)$$

n : Number of lamps lighted at the time of tests

P : Measured value of power input (kW)

Q_{T3} : Actual thermal loads of other heat sources (W)

$\sum A_{Ti} \cdot \Delta T_{Ti}$: Sum of products of the exterior surface area of the heat insulated walls of the refrigerated cargo hold and temperature differences across the wall at the time of heat balance tests (m^2℃)

(The calculated values are to be entered in **Form RMC2-2**.)

A_{Ti}: Exterior surface area of heat insulated walls under the same temperature conditions at the time of heat balance tests (m^2)

ΔT_{Ti} : Temperature difference across the heat insulated walls under the same temperature conditions at the time of heat balance tests (℃)

(1) Example of Method for Calculating Refrigerating Capacity Q_{TC}

(a) Refrigerating cycle method

$$Q_{TC} = \frac{G}{3600}(i_1 - i_4) = \frac{V}{3600} \cdot \eta_m (i_1 - i_4)/v_1 \qquad (18)$$

where:

G : Quantity of refrigerant in circulation (kg/h)

i_1 : Enthalpy of refrigerant vapour at compressor suction (J/kg)

i_4 : Enthalpy of refrigerant liquid right before expansion valve (J/kg)

V : Displacement volume of compressor, to be in accordance with the equation **(19)** or **(20)**

Reciprocating type:

$$V = (\pi D^2/4) \times S \times N \times R \times 60 \ (m^3/h) \qquad (19)$$

Screw compressor

$$V = kB^3 \times (L/B) \times R \times 60 \ (m^3/h) \qquad (20)$$

where:

D : Cylinder bore (mm)

S : Stroke (mm)

N : Number of cylinders

R : Revolutions per minute (rpm)

B : Outside diameter of rotor (mm)

L : Effective length of rotor screw (mm)

k : 0.450 : 2% addendum tooth profile

k : 0.476 : 3% addendum tooth profile

η_m : Volumetric efficiency of compressor

v_1 : Specific volume of suction gas of compressor (m^3/kg)

(b) Brine system of indirect system

Run the refrigerating unit, measure the quantity of brine in circulation and the temperatures, and determine by the following formula:

$$Q_{TC} = \frac{G_b}{60} \cdot \gamma_b \cdot S_b(t_{ob} - t_{ib}) \qquad (21)$$

where:

G_b : Quantity of brine in circulation (l/min)

γ_b : Specific weight of brine (kg/l)

S_b : Specific heat of brine (J/kg ℃)

t_{ob} : Brine temperature at brine cooler outlet (℃)

t_{ib} : Brine temperature at brine cooler inlet (℃)

(c) Method by the quantity of heat rejected at condenser

$$Q_{TC} = Q_W - Q_c = \frac{W}{60} \cdot S_w \cdot \gamma_w(t_{ow} - t_{iw}) - Q_c \qquad (22)$$

where:

Q_W : Quantity of heat dumped at condenser (W)

W : Condenser cooling water flow rate (l/min)

S_w : Specific heat of cooling water (J/kg ℃) = 4186.8

γ_w : Specific weight of cooling water (kg/l) = 1.025 (Sea water)

t_{ow} : Cooling water temperature at condenser outlet (℃)

t_{iw} : Cooling water temperature at condenser inlet (℃)

Q_C : Quantity of heat added by compressor, to be in accordance with the equation (23)

$$Q_C = n \times P \times 1000 \times \eta_m \ (W) \qquad (23)$$

n : Number of motors in service

P : Rated motor output (kW)

η_m : Mechanical efficiency of compressor

1.4 Verification Method of Refrigerating Capacity of Refrigerated Cargo Hold

The values of K_{m1} and K_{max} are stated in the Thermal Calculation Sheet (**Form RMC1**) when designed. For the value of K_{max} for ships planned to carry also fruits, the lower one of the K_{max} for refrigerated cargoes in preference to K_{max} for perishable cargoes is to be employed. The values of K_{m2} are stated in records of heat balance test (**Form RMC2**).

From these values of K_{m1}, K_{max} and K_{m2}, a refrigerating capacity is to be determined by referring to the following formulae of relation:

$$R_1 = \frac{K_{max}}{K_{m1}} \geq 1.2$$

$$R_2 = \frac{K_{m2}}{K_{m1}} \leq 1.1$$

Form RMC1-1

CNo.

Thermal calculation sheets of Refrigerating installations
(Reference to 2.2.1 in Chapter 2 of the Rules for Cargo Refrigerating Installations)

Ship owner_____ Ship's name_____
Ship builder_____ Hull No._____

Particulars of Refrigerating Installations

Notation to be affixed to the installation character
RMC_____

Manufacturer of the installation

_____

Insulation worker

_____

Cooling method:_____
Refrigerant:_____(Primary)_____(Secondary)_____
Compressors: (Capacity)_____set(s)×_____W
(CT=_____℃、ET=_____℃)
(type)_____(manufacturer)_____

(Capacity)_____set(s)×_____W
(CT=_____℃、ET=_____℃)
(type)_____(manufacturer)_____

Condensers: _____sets
Receivers: _____sets
Refrigerant Chamber:
_____Chamber×_____m^3, _____℃ (Temp.)
_____Chamber×_____m^3, _____℃ (Temp.)
_____Chamber×_____m^3, _____℃ (Temp.)
_____Chamber×_____m^3, _____℃ (Temp.)

Form RMC1-2

1. Mean coefficient of overall heat transmission for design of the thermal insulation system (K_{m1})

$$K_{m1} = \frac{Q_{1D}}{\Sigma A_{Di} \cdot \Delta T_{Di}}$$

$$= \text{————} = \qquad (W/m^2{}^\circ\text{C})$$

2. Allowable limit of mean coefficient of overall heat transmission ($K_{\max}$)

$$K_{\max} = \frac{N_1 Q_{Dc} - \Sigma Q_{Di}}{\Sigma A_{Di} \cdot \Delta T_{Di}}$$

$$= \text{————} = \qquad (W/m^2{}^\circ\text{C})$$

$N_1 Q_{Dc}$: Sum of refrigerating capacity during cold storage (W)
ΣQ_{Di} : Total sum of heat loads in the refrigerated cargo hold (W)
Q_{D1} : Heat emission of calculation fan motors in the refrigerated cargo hold ($n \cdot P \cdot 1/\eta_m \cdot 1000\varepsilon/24$)

$=$ (no.) $\times$ $kW \times 1/$ $\times 1000 \times$ $/24$

$=$

Q_{D2} : Heat emission of electric lamps in the refrigerated cargo hold ($n \cdot P \cdot 1000\varepsilon/24$)

$=$ (no.) $\times$ $kW \times 1000 \times$ $/24$

$=$

Q_{D3} : Heat emission by fruits and vegetable ($Q \cdot V \cdot C$)

$=$ $\times$ $\times$

$=$

Q_{D4} : Heat entry associated with the fresh air intaking for fruits ($a \cdot V \cdot \gamma \cdot (i_{a1} - i_{a2})$)

$=$ $\times$ $\times$ $\times($ $-$ $)$

$=$

Q_{D5} : Other heat to be removed

$=$

3. $R_1 = \dfrac{K_{\max}}{K_{m1}} = \text{———} =$

Form RMC1-3

Calculation sheet

$$\left[K_i = \eta (1 + \omega) \frac{1}{\frac{1}{\alpha_1} + \Sigma \frac{d_i}{\lambda_i} + \frac{1}{\alpha_2}} \xi \right]$$

locations		η	ω	ξ	$(W/m^2°C)$ α_1	α_2	$d(m)/\lambda\,(W/m°C)$ d_1/λ_1	d_2/λ_2	d_3/λ_3	d_4/λ_4	(※)	K_i $(W/m^2°C)$

※ additional rate due to deck girders, pillers, manholes, scuppers, etc.

H_i for deck lines and bulkhead lines

locations		H_i $(W/m°C)$

Form RMC1-4

Calculation sheet (Q_{1D})

locations		$A_{Di}(m^2)$ / $L_{Di}(m)$	K_i ($W/m^2°C$) / H_i ($W/m°C$)	($°C$) T_{Da}	($°C$) T_{Dc}	($°C$) $\Delta T_{Di} = T_{Da} - T_{Dc}$	$A_{Di} \cdot \Delta T_{Di}$ ($m^2°C$)	$K_i \cdot A_{Di} \cdot \Delta T_{Di}$ / $H_i \cdot L_{Di} \cdot \Delta T_{Di}$ (W)
ceiling		A_{Di}	K_i					
hatch		A_{Di}	K_i					
coaming		A_{Di}	K_i					
floor (tank top)		A_{Di}	K_i					
ship side (above LWL)		A_{Di}	K_i					
ship side (below LWL)		A_{Di}	K_i					
bulkhead		A_{Di}	K_i					
Deck line etc.		L_{Di}	H_i					
Others								

(1) $\Sigma A_{Di} \cdot \Delta T_{Di} =$

(2) $Q_{1D} = \Sigma K_i \cdot A_{Di} \cdot \Delta T_{Di} + \Sigma H_i \cdot L_{Di} \cdot \Delta T_{Di}$

Form RMC2-1

Heat balance calculation sheets
(Reference to 6.2.6 in Chapter 6 of the Rules for Cargo Refrigerating Installations)

Ship owner_____ Ship's name_____
Ship builder_____ Hull No._____
Insulation worker_____
Manufacturer of the installations_____
This report is submitted by_____

Mean coefficient of overall heat transmission inferred from the results of measurement by heat balance test (K_{m2})

$$K_{m2} = \frac{N_2Q_{TC} - \Sigma Q_{Ti}}{\Sigma A_{Ti} \cdot \Delta T_{Ti}}$$

$$= \text{————————} = \qquad (W/m^2{}^\circ C)$$

N_2Q_{TC} : Sum of refrigerating capacity at the time of heat balance test (W)

$=$ $\times$ $=$

ΣQ_{Ti} : Sum of thermal loads in the refrigerated cargo hold at heat balance test (W)

Q_{T1} : Heat emission from in-hold air circulation fans (W) $(n \cdot P \cdot 1000)$

$=$ (sets) $\times$ $kW \times 1000 =$

Q_{T2} : Heat emission from lamps (W) $(n \cdot P \cdot 1000)$

$=$ (no.) $\times$ $kW \times 1000 =$

Q_{T3} : Actual thermal loads of other heat sources

$=$

$$R_1 = \frac{K_{\max}}{K_{m1}} = \text{———} =$$

$$R_2 = \frac{K_{m2}}{K_{m1}} = \text{———} =$$

Surveyor to NK,

Form RMC2-2

Calculation sheet ($\Sigma A_{Ti} \cdot \Delta T_{Ti}$)

locations		A_{Ti} (m^2)	(°C)			$A_{Ti} \cdot \Delta T_{Ti}$ ($m^2 \cdot °C$)
			T_{Ta}	T_{Tc}	$\Delta T_{Ti} = T_{Ta} - T_{Tc}$	
ceiling						
hatch						
coaming						
floor (tank top)						
ship side (above *LWL*)						
ship side (below *LWL*)						
bulkhead						
Others						

(1) $\Sigma A_{Ti} \cdot \Delta T_{Ti} =$

Appendix 1 SPARE PARTS (FOR REFERENCE)

1.1 Spare Parts for General Tools and Equipment

(1) One set of motor coupling bolts with nuts and washers of each size used.
(2) One expansion valve of each size used.
(3) One float regulator assembly of each size used.
(4) At least two glass thermometers.
(5) In the case of thermometers:
5% of the total number of temperature sensors, but not less than one of each type used.
Two sets of standard resisters of each size used.
(6) Two sets of relief valves of each size used.

1.2 Spare Parts for Refrigerant Compressors

(1) Where screw type compressors are installed, the following spare parts are to be provided.
(a) One set of main bearing of each size used.
(b) One set of thrust bearing of each size used.
(c) One set of rotor seals of each size used.
(2) Where reciprocating compressors are installed, the following spare parts are to be provided.
(a) One set of piston and piston rod or connecting rod of each size used.
(b) One set of crankshaft main bearing of each size used.
(c) One complete assembly of each size of compressor suction and delivery valves.
(d) One set of wearing parts of the crankshaft seals where the crankcase is subjected to the refrigerant pressure.
(e) One set of crankshaft coupling bolts with nuts and washers of each size used.
(f) One set of driving belts of each size used.

1.3 Spare Parts for Electrical Equipment

Spare parts for the electrical equipment are to comply with the requirements in **3.8, Part H of the Rules for the Survey and Construction of Steel Ships**.