TÜRK LOYDU

Chapter 15 - Rules For The Construction Of Refrigerating Installations

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This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to crafts for which the date of contract for construction is on or after 01st of January 2016 . New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on **TL** website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

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Rules For The Construction Of Refrigerating Installations

RULES FOR THE CONSTRUCTION OF REFRIGERATING INSTALLATIONS

Page

A. General

1. Scope

The Rules for construction of refrigerating installations apply to all the machinery and hull equipment of the refrigerating installation serving the ship's cargo.

The safety requirements of these Rules also apply to refrigerating installations not subject to classification, provision refrigerating installations and air conditioning refrigerating installations; see also Chapter 4, Section 1, D.17.

2. Definitions

Within the meaning of these Rules, refrigerating installations on seagoing ships are:

- Cargo refrigerating installations for the refrigeration of insulated cargo holds, and
- Container refrigerating installations for the refrigeration of insulated containers.

The provisions assume that the refrigerating installations are permanently installed and belong to the ship.

3. Classification of Refrigerating Installations

3.1 For the classification and characters of classification of refrigerating installations, see Classification and Surveys, Section 2.

3.2 For surveys of refrigerating installations, see Classification and Surveys, Section 3.

4. Deviation From the Rules

For the fulfillment of its function as a Classification Society, **TL** reserves the right to modify or amend the present Rules as it deems necessary in the light of practical experience, Technical progress and special design requirements.

5. Documents for Approval

5.1 For refrigerating installations which are built under the supervision and in accordance with the Rules of the **TL**, each of the following documents is to be submitted to the **TL** in triplicate in due time:

a) A description of the refrigerating installations to provide the information necessary for the classification of refrigerating installations.

b) A calculation of the cooling load as evidence of the adequate capacity of the installation.

c) A general arrangement plan of the refrigerating installation with details of the ventilation of the refrigerating machinery spaces.

d) Drawings of the compressors (longitudinal and transverse sections) and a workshop drawing of the crankshaft or rotors.

e) Performance data of the compressors.

f) Drawings of all vessels and equipment under refrigerant pressure, e.g. condensers, evaporators and oil separators as well as brine tanks and air coolers, together with details of the materials used.

g) Diagrams showing the layout of refrigerant, brine and cooling water pipelines with details of the wall thicknesses and materials of the pipes.

h) Drawings showing the arrangement and equipment of the refrigerated spaces or container holds with details of air circulation and space ventilation including air ducts and temperature- measuring equipment.

i) Drawings showing the type and design of the defrosting system.

j) Drawings showing the type and execution of the insulation used for the refrigerated spaces and air ducts, with details of the insulation of hatches, doors, covers for scuppers and bilges, thermal bridges, and refrigerant and brine piping.

k) Drawings of the bilge pumping and drainage facilities in refrigerated and air cooler spaces.

l) Drawings and descriptions of electrical temperature-monitoring systems with details covering extent of the system, the arrangement, number and coordination of the measuring the points and instruments, measuring ranges, accuracy, wiring etc.

m) Description of automatic control systems.

5.2 Where the ship's machinery is not built under the supervision of **TL** or of another recognized Classification Society, plans of the power supply plant have also to be submitted together with the documents relating to the refrigerating installation.

5.3 Re-submission of drawings of installation components for which the drawings have already been approved by **TL** is not required.

6. References to other rules

6.1 In addition to this Chapter, the following rules are to be observed:

- Classification and Surveys, Sections 1, 2 and 3
- Rules for Classification and Construction Seagoing Ships:
  Chapter 1, Hull
  Chapter 4, Machinery
  Chapter 5, Electrical Installations
- Materials, Chapter 2
- Welding, Chapter 3

6.2 Container refrigerating units and containers with and without refrigerating units are subject to Chapter 55, Regulations for the Construction, Repair and Testing of Freight Containers.

6.3 Guidelines for Systems with Controlled Atmosphere on Ships are applicable in respect of the carriage of cargo under a controlled atmosphere.

6.4 Ships for the transport of refrigerated liquefied gases are subject to the provisions of Chapter 10, Liquefied Gas Tankers.

7. Testing

7.1 Operational Tests

7.1.1 Refrigerating machines are to be subjected to operational tests at the manufacturers' as specified in relevant items of this chapter.

7.1.2 Fitting of the refrigerating installation will be supervised by the Surveyor, who will examine the workmanship and perform the prescribed tightness and operational tests.

7.1.3 Upon completion the entire installation will be subjected to operational trials (refer to item P.1).

7.2 Material Tests

The selection and testing of materials is subject to Chapter 2, Material.

7.2.1 All components under refrigerant pressure are required to undergo material testing as a matter of principle. Subject to the requirements in G.3., components of refrigerant compressor casings, refrigerant circulating pumps and refrigerant valves and fittings are exempted from this Rule.

7.2.2 Materials tests are to be performed on the crankshafts of reciprocating compressors and the rotors of screw compressors with a calculated journal diameter of more than 50 mm. Works certificates are sufficient for journal diameters of ≤ 50 mm.

7.2.3 **TL** reserves the right to extend material testing to other important plant components.

B. Installation Design and Rating

1. Electrical Power Supply

At least two generating sets must be available for supplying power to refrigerating installations. The capacity of the generators is to be such that, in addition to other requirements:

- When all the generators are in operation, the total power requirements of the refrigerating installation can be satisfied, the "total power requirements" being the installed electrical load of the refrigerating installation;

- In the event of the failure or shutdown of any one generator, all refrigerating machinery, with the exception of the stand-by sets, can be operated at full load.

2. Number of Refrigerating Units

2.1 At least two complete refrigerating units are to be installed for each refrigerating installation or autonomous group thereof.

2.2 For the purpose of the present Rules a refrigerating unit comprises one refrigerant compressor and driving engine, one condenser and, in the case of indirect evaporation with brine as cooling medium, one brine cooling evaporator.

2.3 Where several compressors operate in a closed circuit with one condenser and, where installed, one brine cooling evaporator, this also counts as one refrigerating unit.

2.4 Where only two refrigerating units are installed, each compressor must be capable of working with each condenser and, where applicable, with each brine cooling evaporator.

3. Refrigerating Capacity

3.1 The refrigerating capacity of the installation is to be rated in such a way that, should any particular refrigerating unit fail, the required refrigerated space or refrigerated container temperatures can be maintained. The required refrigerated space or refrigerated container temperature is the temperature on which the cooling load calculation is based and which is certified in the Refrigerating Installation Certificate.

3.2 For refrigerating installations comprising a large number of refrigerant compressors or refrigerating units, the number of compressors or units to be provided as stand-by capacity is to be agreed with **TL**. This stand-by capacity shall not, however, be less than 10 %.

3.3 If the liquefied refrigerant is subcooled with the aid of additional devices, e.g. heat exchangers, another such device with the same capacity is to be provided as a stand-by.

This stand-by unit may be dispensed with if it is demonstrated to **TL** that the available compressors for refrigerating spaces or containers, including the stand-by compressor, are capable of maintaining the stipulated temperatures in the refrigerated spaces or refrigerated containers without subcooling the refrigerant.

4. Factors Affecting Plant Rating

4.1 The calculation of the required refrigerating capacity is to be based on a seawater temperature of at least 32 °C and on an ambient air temperature of at least 40 °C with 55 % relative humidity unless other values are agreed with **TL** in consideration of special trade.

4.2 The calculation shall likewise be based on the area enveloping the refrigerated spaces on the inside of the insulation, where such spaces are adjacent to non-cooled spaces, cooled spaces at higher temperatures, the ambient air or seawater.

4.3 Where a ship is equipped with several mutually independent refrigerating installations, the calculation of the refrigerating capacity required is to be based on each group of spaces belonging to one installation considered in isolation and as though surrounded by non-cooled spaces, if no limiting qualifications are to be entered on the Refrigerating Installation Certificate.

5. Calculation of Refrigerating Capacity For Fruit Cargo

5.1 The calculation of the necessary refrigerating capacity is required to prove that the rating of the installation is sufficient to cool down the cargo within a reasonable period of time. All refrigerating units and pumps, including the stand-by sets, may be in operation during the cooling-down period.

5.2 Under steady operating conditions, allowance is to be made for the fan heat generated with the maximum air circulation and for the simultaneous introduction of a reasonable quantity of fresh air.

6. Calculation of Refrigerating Capacity For Deep-Frozen Cargo

6.1 For deep-frozen cargo, no arrangements need normally be made for cooling down the cargo.

6.2 Unless otherwise agreed, the introduction of fresh air can be dispensed with. The fan heat to be applied in the calculation may be based on a reduced air circulation where this is intended for the deep-frozen cargo.

7. Automation

7.1 Automated refrigerating installations are to be so equipped that they can also be operated with manual control.

7.1.1 Input units and actuating devices are to be type-tested; see also Chapter 4-1, Section 7, E.

7.2 Steps must be taken to prevent the temperature in the inlet ducts from falling below the minimum permitted level.

7.3 For the following faults alarm systems are to be installed which actuate an alarm at a position which is constantly manned.

7.3.1 Temperature of return air or air in space exceeding the maximum permitted level. A temperature instrument on the bridge may be accepted as an alternative.

7.3.2 Failure of circulating fans.

7.3.3 Permitted level exceeded in bilges or bilge wells of refrigerated spaces.

7.3.4 Suction pressure of refrigerant below permitted level.

7.3.5 Condensation pressure of refrigerant above permitted level.

7.3.6 Lubricating oil pressure below required level.

7.4 If any of the faults in 7.3.4, 7.3.5 and 7.3.6 occur, the installation must automatically shut down.

8. Plant of Novel Design

Refrigerating installations differing in design from those which have already proved suitable in service on board ship are subject to **TL**'s special approval.

For such installations, **TL** may impose special requirements as to the extent of the documentation to be submitted for approval and reserves the right to require additional tests to be performed, schedule special survey dates and make special entries in the refrigerating installation certificate and in the Register.

C. Refrigerants

1. Classification

Refrigerants are classified as follows:

1.1 Approved refrigerants, Group 1

Incombustible refrigerants without significant hazard to human health, e.g.:

R22	Chlordifluormethane	$CHClF_2$ **(1)**
R134a	Tetrafluorethane	CH_2F- CF_3
R404A	R125/143a/134a(44/52/4%)	
R407A	R32/125/134a(20/40/40%)	
R407B	R32/125/134a(10/70/20%)	
R407C	R32/125/134a(23/25/52%)	
R410A	R32/125 (50/50%)	
R507	R125/143a (50/50%)	

(1) *In accordance with MARPOL Annex VI, Regulation 12, 3.2, Installations which contain hydro-chlorofluorocarbons shall be prohibited on ships constructed on or after 1 January 2020; or in the case of ships constructed before 1 January 2020, which have a contractual delivery date of the equipment to the ship on or after 1 January 2020 or, in the absence of a contractual delivery date, the actual delivery of the equipment to the ship on or after 1 January 2020.*

With these refrigerants the danger of asphyxiation is, however, to be borne in mind.

1.2 Approved refrigerants, Group 2

Toxic or caustic refrigerants or those which, when mixed with air, have a lower explosion limit of at least 3,5 % by volume.

R717 Ammonia NH_3

Ammonia may not be used in refrigerating plants operating with direct evaporation. In addition, the regulations imposed by the competent authorities of the country of registration are to be observed.

1.3 Refrigerants which are not approved, Group 3

Refrigerants which, when mixed with air, have a lower explosion limit of less than 3,5 % by volume, e.g. ethane, ethylene.

2. Working Pressures

2.1 For the more common refrigerants, the allowable working pressures PB (design pressures PR) are laid down in Table 1.

Table 1

Refrigerant	Working pressures [bar]	
	High-pressure side (HP)	Low-pressure side (LP)
R 22	22,5	17,0
R134a	13,9	10,6
R404A	25,0	19,7
R407A	25,2	19,8
R407B	26,5	20,9
R407C	23,9	18,8
R410A	33,6	26,4
R507	25,6	20,2
R717 (NH_3)	24,0	17,5

For other refrigerants, the design pressures PR are determined by the pressure at the bubble point at a temperature of 55 °C on the high pressure side and at a temperature of 45 °C on the low-pressure side

2.2 Within the meaning of these Rules, the low-pressure side of the plant includes all parts exposed to the evaporation pressure of the refrigerant. However, these parts are also subject to the design pressure for the high-pressure side if (e.g. for hot gas defrosting) a switch-over of the system can subject them to high pressure. Medium-pressure vessels of two-stage plants form part of the high-pressure side.

3. Storage or Reserve Supplies of Refrigerants

3.1 On board ship, reserve supplies of refrigerants may be stored only in steel bottles approved for this purpose by the competent authorities of the country of registration.

3.2 The level of filling of these bottles must be suitable for tropical conditions.

3.3 Bottles containing refrigerant are to be securely anchored in an upright position and protected against overheating.

3.4 Bottles containing refrigerant may be stored only in well ventilated spaces specially prepared for this purpose or in refrigerating machinery spaces.

3.5 On ships where (with due regard for the provisions of D.) there is no refrigerating machinery space and the refrigerating machinery is installed in the main or auxiliary engine room, **TL** may permit exceptions to 3.4 in the case of refrigerants belonging to Group 1. The storage bottles immediately required for replenishing the system, up to a maximum of 20 % of the total refrigerant charge, may then be kept in the main or auxiliary engine room

D. Refrigerating Machinery Spaces

1. Definitions

Within the meaning of these Rules, refrigerating machinery spaces are spaces separated by bulkheads from other service spaces and housing refrigerating machinery and the associated equipment.

2. Installation of Refrigerating Machinery

Even if not installed in specially designated spaces, refrigerating machinery is to be installed in such a way that sufficient space is left for operation, servicing and repair.

3. Equipment and Accessories

3.1 Refrigeration systems using ammonia in charges exceeding 25 kg are to be installed in refrigerating machinery spaces separated by gastight divisions from other ship spaces and service rooms.

3.2 Regardless of the type of refrigerant used, the doors of refrigerating machinery spaces shall not give access to living quarters or corridors in the accommodation area. The doors must open outwards and be self-closing.

3.3 Where refrigeration systems operate with ammonia spaces accommodating the refrigerating machinery are to be equipped as follows:

a) Spaces must be provided with at least two access doors located as far as possible from each other.

b) Type-tested gas detectors are to be fitted. Visual and audible signals must be provided outside and inside the room. The alarm is to be linked to the general machinery alarm system and is to trip an individual alarm on the bridge as well as in the engine control room.

c) Equipment for producing water screens is to be fitted above the entrances to refrigerating machinery spaces. Provision must be made for actuating this equipment from outside the refrigerating machinery space. The actuating device shall not be located in the immediate vicinity of the entrances.

Where water sprinklers are additionally mounted in the refrigerating machinery spaces themselves, these are to be permanently installed and must also be capable of being actuated from outside.

The spray nozzles of sprinkler systems are to be suitably distributed in the refrigerating machinery space. Due attention is to be paid to electrical machinery and equipment. The spray nozzles shall be capable of covering as large an area as possible with fine water droplets.

d) The electrical consumers in the refrigerating machinery spaces must be capable of being switched off, independently of the forced ventilation system, by a central switch located outside the room.

3.4 Provision must be made for the bilge pumping or drainage of refrigerating machinery spaces. Where refrigeration systems are operated with ammonia, the refrigerating machinery spaces must not be drained into the open wells or bilges of other spaces.

3.5 The electrical equipment of refrigerating machinery spaces is subject to the provisions of Chapter 5, Electrical Installation.

3.6 In the case of refrigeration systems which use ammonia, suitable protective clothing, as well as goggles and breathing apparatus for at least two people must be provided outside the refrigerating machinery space close to the access door. **(2)**

(2) *Additional national requirements, e.g. self-contained air breathing apparatus and protective clothes are to be observed.*

4. Ventilation

4.1 Refrigerating machinery spaces must be provided with a suitably arranged forced ventilation system. With Group 1 refrigerants, at least the exhaust air is to be conveyed into the open air independently of other space ventilation ducting. The inlet ducting shall not be connected to the ventilation system serving the accommodation spaces.

4.2 Where ammonia is used, the ventilation of the refrigerating machinery space shall be independent from ventilation systems of other spaces in the ship. The ventilation system is to be of exhaust type.

4.3 Within the ship, the exhaust air ducts of fans serving refrigerating machinery spaces are to be gastight. The exhaust air must be conveyed in such a way as to prevent entrance of gas into other ship spaces.

4.4 Provision must be made for starting and stopping the fans of refrigerating machinery spaces from outside the spaces in question. The switches are to be clearly marked.

4.5 The rating of forced ventilation systems is subject to the following rules:

a) For refrigerating machinery spaces with Group 1 refrigerants, forced ventilation is required which ensures at least 30 changes of air per hour.

b) For refrigerating machinery spaces in which ammonia is used as refrigerant, the minimum capacity of the fan is to be determined by the formula:

$$V=60\ \sqrt[3]{M^2}$$

However, the number of air changes per hour shall not be less than 40.

In the above formula:

V capacity of fan [m^3/h]

M charge of refrigerant in system [kg].

In the case of refrigeration systems using ammonia installed in rooms with an effective sprinkler system, the minimum required capacity of the fans indicated above may be reduced by 20 %.

E. Refrigerant Compressors

1. General

1.1 Where the compressors are electrically driven, the motors and other items of electrical plant must comply with Chapter 5, Electrical Installation.

1.2 Other compressor drives (diesel engines, turbines) must comply with Chapter 4, Machinery.

2. Reciprocating compressors

2.1 Shaft journal and crank pin diameters are to be determined as follows:

$$d_k = 0{,}115 \cdot \sqrt[3]{D^2 \cdot P_c \cdot C_1 \cdot C_w \cdot (0{,}3 \cdot H + f \cdot L)}$$

where:

d_k = minimum journal or pin diameter [mm]

D = cylinder diameter [mm]

P_c = design pressure PR [bar]

according to Table 1, working pressures on the high-pressure side

H = piston stroke [mm]

L =center distance between two main bearings [mm], where one crank is located between two main bearings; L is to be replaced by $L_1 = 0{,}85$ L, where two cranks at different angles are located between two main bearings, and by $L_2 = 0{,}95 \cdot L$, where two or three connecting rods are located next to each other on one crank

f = factor relating to cylinder arrangement [–]:

= 11,0, where the cyl. are in line

= 1,2, where the cyl. make an angle of 90°

V or W arrangement

= 1,5, where the cyl. make an angle of 60°

= 1,8, where the cyl. make an angle of 45°

C_1 = coefficient according to Table 2 [–]

Z = number of cylinders [–]

C_w = material factor according to Table 3 or Table 4 [–]

R_m = minimum tensile strength [N/mm^2]

2.2 Where higher strength is achieved by a favourable crankshaft geometry, lower values of d_k may be allowed.

3. Screw Compressors

The documents listed under A.5.1 d) and e) are to be submitted.

4. Turbo Compressors, Special Types

Where turbo compressors or special types are used as refrigerant compressors for refrigerating installations, detailed documentation is to be submitted for assessment.

Suitable evidence of the functional reliability is to be furnished to **TL** prior to the first shipboard application of any type.

5. Material Testing

Refrigerant compressors and compressor parts are to be subjected to material testing in accordance with A.7.

6. Equipment

6.1 Provisions have to be made (e.g. in the form of overpressure safety switches) to ensure that the compressor drive switches off automatically should the maximum allowable working pressure be exceeded.

6.2 Compressors are to be equipped with devices such as pressure relief valves, rupture discs, etc., which, if the maximum allowable working pressure is exceeded, will equalize the pressures on the discharge and suction sides.

Semi-hermetic compressors in automatic installations may be exempted from this Rule, provided that they are protected by overpressure safety switches and can be operated with permanently open shutoff valves in such a way that the safety valves fitted to the installation remain effective.

Tablo 2 C_1 values cast iron

Z	1	2	4	6	≥8
C_1	1,0	1,1	1,2	1,3	1,4

Table 3 Values of C_w for shafts of nodular graphite

R_m	370	400	500	600	700	≥800
C_w	1,20	1,10	1,08	0,98	0,94	0,90

6.3 Air-cooled compressors are to be designed for an air temperature of at least 45°C.

6.4 For sea water cooling, a minimum inlet temperature of 32 °C is to be applied. The cooling water spaces, unless provided with a free outlet, are to be protected against excessive overpressure by safety valves or rupture safety devices.

Table 4 Values of C_w for steel shafts

R_m	400	440	480	520	560	600	640	≥680	720 **(1)**	≥760 **(1)**
C_w	1,03	0,94	0,91	0,85	0,79	0,77	0,74	0,70	0,66	0,64
(1) *For drop-forged crankshafts only.*										

6.5 Pressure gauges and thermometers are to be fitted in accordance with J.2.1 and J.2.2.

6.6 A manufacturer's plate bearing the following information is to be permanently fixed to each refrigerant compressor:

Manufacturer, year of construction, refrigerant and maximum allowable working pressure in [bar].

7. Testing

After completion, refrigerant compressors are to be subjected to a trial run without refrigerant at the manufacturer's works and to the pressure and tightness tests specified in K.

F. Pressure Vessels and Apparatuses

1. Pressure Vessels and Apparatuses Under Refrigerant Pressure

1.1 General

Pressure vessels and apparatuses under refrigerant pressure must comply with Chapter 4, Machinery, Section 14.

1.2 Material testing

The materials of components under refrigerant pressure must be tested in accordance with **TL** Rules for Materials.

1.3 Safety devices

1.3.1 Pressure vessels and apparatuses which contain liquid refrigerant and which can be shut off are to be fitted with a safety valve. For the design of safety valves see J.1.

1.3.2 Filters and driers need not be fitted with safety valves provided that the refrigerant inlets and outlets cannot inadvertently be closed at the same time.

1.4 Pressure and tightness tests

After completion, pressure vessels and apparatuses under refrigerant pressure are to be subjected to the pressure and tightness tests specified in K.

2. Brine Tanks

2.1 General

2.1.1 For the purposes of the present Rules, the term "brine" as a cooling medium means a solution of industrial salts. The use of other media with a low freezing point requires the approval of **TL**.

2.1.2 In this context, brine tanks do not include brine cooling evaporators. The latter must comply with the requirements for pressure vessels and apparatuses under refrigerant pressure, as set out in 1.

2.1.3 Brine tanks may not be galvanized on the side in contact with the brine.

2.1.4 Brine systems must be equipped with air pipes which cannot be closed off and with brine compensating tanks.

2.1.5 Brine tanks which can be shut off must be protected against excessive pressure rises due to the thermal expansion of the brine by the provision of safety valves or by a mechanism for interlocking the shut off devices in the open position.

2.2 Testing

Brine tanks are to be subjected in the manufacturer's works to the hydraulic pressure and tightness tests specified in K. Material tests and pneumatic tightness tests may in general be dispensed with.

3. Air Coolers

3.1 General

3.1.1 Air coolers which work by direct evaporation **(3)** count as apparatuses under refrigerant pressure and are therefore subject to the requirements in 1. Notwithstanding this, safety devices are required only for flooded evaporators.

3.1.2 Air coolers which work by indirect evaporation, in so far as brine is used as the cooling medium are subject to the application in analogous manner of the Rules set out in 2.1.3, 2.1.5 and G.2.

3.1.3 Air coolers are to be designed for a maximum temperature difference between cooling medium and cooling air at the air cooler inlet of about 5 K for fruit cargo and about 10 K for deep-frozen cargo.

3.1.4 Where warranted by the temperature of the refrigerated space, air coolers are to be fitted with the means for defrosting. Defrosting by means of spraying with water is to be avoided. Provision is to be made for heating the drains. In automated plants, the heating equipment is to be controlled by the defrosting program.

3.1.5 Where finned-tube or multi-plate type air coolers are used, the distance between the fins or plates should not be less than 10 mm, at least on the air inlet side. In this context, the air inlet side is taken to mean 1/4 of the length of the cooler measured in the direction of air flow. Where, in container refrigerating installations, an air cooler is provided for each container, a minimum distance of 6 mm between the fins or plates is permissible

3.1.6 Depending on the type of air circulation system employed, the air coolers are to be subdivided by shut offs in such a way that, even after the breakdown of one air cooler section, the cooling of the refrigerated space or containers concerned can be maintained.

The subdivision can be dispensed with where an air cooler is provided for each stack of containers or for each container.

3.1.7 Air coolers must be made of corrosion resistant material or be protected against corrosion by galvanizing.

3.1.8 Air coolers are to be provided with drip trays and adequate drains.

3.2 Material testing

In accordance with A.6. materials for air coolers using direct evaporation must be subjected to the tests specified in Chapter 2, Material.

In the case of air coolers for indirect evaporation, the testing of materials may be dispensed with if the cooling medium employed is brine.

3.3 Pressure and tightness tests

Air coolers are to be subjected to the pressure and tightness tests specified in K., in the manufacturer's works.

In the case of air coolers for indirect evaporation, the pneumatic tightness test may be dispensed with.

G. Pipes, Valves and Fittings

1. Refrigerant Pipes

1.1 General

1.1.1 Refrigerant pipes are to be designed in accordance with **TL** Chapter 4, Machinery, Section 16, C.1.1.

(3) *For the purpose of these Rules refrigerating installations with direct evaporation are those where the refrigerant evaporator is located in the refrigerated space itself or is connected to the latter, or to the containers, via air ducts. It follows that in such plant no brine or similar cooling medium is used.*

1.1.2 When installing refrigerant pipes, care is to be taken to provide all pipes whose working temperatures are below the normal ambient temperatures with insulation in accordance with L.1. These pipes are to be protected externally against corrosion. Unless some other form of corrosion protection has been demonstrated to **TL** to be equally effective, steel pipes are to be galvanized on the outside.

1.1.3 At points where they are supported or pass through decks or bulkheads, the refrigerant pipes mentioned in 1.1.2 may not come directly into contact with steel members of the ship's structure.

1.1.4 Where necessary, refrigerant pipes between compressors and condensers are to be protected against being inadvertently touched.

1.2 Material testing

Materials for refrigerant pipes must be tested in accordance with Chapter 2, Material.

1.3 Tightness tests

After installation, all refrigerant pipes are to be subjected to the tightness test specified in K.

2. Brine Pipes

2.1 General

2.1.1 Brine pipes must comply with **TL** Chapter 4, Machinery, Section 16; they may not be galvanized on the inside, but must be protected externally against corrosion.

2.1.2 In general, use is to be made of thick-walled pipes in accordance with **TL** Chapter 4, Machinery, Section 16, Table 16.7, Group M.

2.1.3 In the case of brine being used whose neutrality during subsequent operation is suitably ensured, the use of externally galvanized brine pipes with the minimum wall thicknesses specified in **TL** Chapter 4, Machinery, Section 16, Table 16.7, Group N, may be permitted. This also applies to non-galvanized pipes which are uninsulated and which can be externally inspected and maintained at all times.

2.1.4 Where brine pipes pass through inaccessible spaces, their wall thicknesses are required to comply with **TL** Chapter 4, Machinery, Section 16, Table 16.7, Group D. The pipes and their insulation are to be installed in such a way that they are protected against damage.

2.1.5 At points where they are supported or pass through decks or bulkheads, brine pipes may not come directly into contact with steel members of the ship's structure.

2.2 Testing

After being installed but prior to the application of the insulation, brine pipes are to be subjected to the hydraulic pressure and tightness tests specified in K.

Material tests and pneumatic tightness tests may generally be dispensed with.

3. Refrigerant valves and fittings

3.1 General

Refrigerant valves and fittings must comply with **TL** Chapter 4, Machinery, Section 16.

Automatic control valves are to be arranged or fitted with by-passes so that the installation can also be operated by hand.

3.2 Testing

3.2.1 Refrigerant valves and fittings are subject to material testing if their housings are made of cast steel or nodular graphite cast iron and the product of the maximum allowable working pressure PB [bar] multiplied by the nominal diameter DN [mm] is > 2500. Valves and fittings with DN ≤ 32 are exempted from this Rule.

3.2.2 Where the housings of valves and fittings are manufactured by drop forging or are made of copper alloys, material testing is not required.

3.3 Pressure and tightness tests

3.3.1 Refrigerant valves and fittings are to be subjected in the manufacturer's works to the pressure and tightness tests specified in K.

3.3.2 Automatic control valves can be exempted from this requirement where the danger exists that sensitive internal components will be damaged by the pressure imposed in the pressure test. Where the design permits, the housings are to be tested without internal components in these cases.

4. Brine Valves and Fittings

4.1 General

Brine valves and fittings must comply with **TL** Chapter 4, Machinery, Section 16. The requirements specified in 2.1.1 also apply.

4.2 Testing

After being installed but prior to the application of the insulation, brine valves and fittings are to be subjected to the hydraulic pressure and tightness tests specified in K.

Material tests and pneumatic tightness tests may generally be dispensed with.

H. Fans and Pumps

1. Fans

Motors driving the circulating fans of refrigerated holds must comply with **TL** Chapter 5, Electrical Installation. This also applies to motors driving the intake and exhaust fans of ships carrying fruit cargo.

After being installed the fans are to be tested in accordance with P.1.5.

Provision must be made for replacing fan impellers and fan motors even when the refrigerated holds are fully loaded.

2. Refrigerant Circulating Pumps

2.1 At least two mutually independent pumps are to be installed, one of which is to act as a stand-by.

2.2 Evidence of the quality of the materials used is to be supplied in respect of all parts subject to refrigerant pressure.

2.3 Motors driving refrigerant circulating pumps must comply with **TL** Chapter 5, Electrical Installation

2.4 Refrigerant circulating pumps are to be subjected in the manufacturer's works to a performance test and to the pressure and tightness tests specified in K.

3. Brine pumps

3.1 At least two mutually independent pumps are to be installed, one of which is to act as a stand-by. These pumps must be of well established design.

3.2 Motors driving brine pumps must comply with **TL** Chapter 5, Electrical Installation.

3.3 Brine pumps are to be subjected in the manufacturer's works to a performance test and to the hydraulic pressure and tightness tests specified in K. A pneumatic tightness test is not required.

4. Cooling Water Pumps

The requirements set out in 3. are applicable in analogous manner. Regarding the possible deletion of the stand-by pumps see I.2.

I. Cooling Water Supply

1. General

Pipes, valves and fittings must comply with **TL** Chapter 4, Machinery, Section 16.

A suitable automatic cooling water control system is to be provided for the condenser pressure. Exceptions require **TL** approval.

2. Reserve Cooling Water Supply

Where the reserve cooling water supply system of the refrigerating installation is connected to the cooling water system of the main propulsion plant, the standby cooling water pump specified in H.4. may be dispensed with provided that the stand-by cooling water pump of the main propulsion plant is capable of the adequate supply of cooling water to the refrigerating installation without adversely affecting the operation of the main propulsion plant.

3. Suction Lines

Each cooling water pump must be equipped with its own suction line and must be able to draw from at least two sea chests. Seawater filters are to be fitted and so arranged that they can be cleaned without interrupting the cooling water supply.

4. Dock Operation

By suitable connection of the cooling water lines to ballast water tanks or by hose connections to the deck-washing line or fire main, steps shall be taken to ensure that, when necessary, the refrigerating installation can also be operated while the ship is docked.

5. Cooling Water Pipes in Cargo Holds

Where cooling water pipes have to be laid through cargo holds or refrigerated cargo holds to the refrigerating machinery spaces, they are to be installed in pipe tunnels. In exceptional cases cooling water pipes may be installed above deck or in the double bottom tank.

Where cooling water pipes pass through double bottom tanks, their wall thickness is required to comply with **TL** Chapter 4, Machinery, Section 16, Table 16.6.

6. Testing

After being installed, cooling water pipes, valves and fittings are to be subjected to the pressure and tightness tests specified in K.

J. Safety and Monitoring Equipment

1. Safety Equipment

1.1 General

1.1.1 Provisions are to be made to ensure that if the maximum allowable working pressure according to C.2. is exceeded, the compressor drive switches off automatically.

1.1.2 Pressure vessels and apparatuses which can be isolated and which contain liquefied refrigerants must be equipped with a safety valve; see also F.1.3.

1.1.3 Provision must be made for the safe blow-off of refrigerants directly into the open air.

1.2 Safety valves and rupture discs

1.2.1 Safety valves exposed to refrigerant pressure are subject to the requirements set out in G.3. The provisions of G.4. are applicable in analogous manner to safety valves under brine pressure.

1.2.2 Safety valves are to be set to the maximum allowable working pressure and secured to prevent the setting from being altered inadvertently.

1.2.3 Fitting a rupture disc in front of a safety valve is permitted only where, between the rupture disc and the safety valve, no uncontrolled pressure build-up can occur which, in the event of a sudden pressure surge, would not allow either the safety valve or the rupture disc to respond.

The space between the rupture disc and the safety valve cone must therefore be fitted with an alarm pressure gauge or equivalent device. Instead of this a free outlet duct may also be used, provided that it traverses oil-filled sight glasses or the like which reveal any leakage through the rupture disc. A screen for the retention of broken fragments is to be fitted behind the rupture disc.

1.2.4 Where rupture discs are used, **TL** requires evidence that the bursting pressure does not exceed the maximum allowable working pressure. A 10 % margin of tolerance is permitted.

2. Monitoring Equipment

2.1 Pressure gauges

The suction and pressure pipes of refrigerant compressors, intermediate stage pressure vessels and pressurized brine pipes are to be fitted with pressure gauges. Refrigerant pressure gauges are required to have pressure and temperature scales for the refrigerant concerned. The maximum allowable working pressure is to be indicated by a red line.

2.2 Thermometers

Brine delivery and return pipes, condenser cooling water inlet and outlet pipes and pressure and suction pipes of compressors are to be fitted with thermometers. For the number and disposition of thermometers in refrigerated cargo holds and in the air duct systems of refrigerated containers, see N.

2.3 Liquid level indicators

Direct indicators such as sight glasses for liquid refrigerants used in plants operated with ammonia are to be so designed that they can be shutoff.

The use of tubular glasses is not permitted.

K. Pressure and Tightness Tests

1. General

1.1 All pressure tests are to be performed in the presence of a Surveyor. They are to be carried out initially during supervision of construction at the manufacturer's works or, in the case of a survey for the assignment of class, on board ship.

1.2 For repeat tests, see **TL** Classification and Surveys, Section 3.

1.3 As a rule, pneumatic tightness tests are to be performed after the hydraulic pressure tests.

1.4 Exceptionally, **TL** may, on application, waive the hydraulic pressure test provided that a pneumatic pressure test is performed at the test pressure specified for the hydraulic test. **(4)**

1.5 In refrigerating installations which have already been charged with refrigerant, pneumatic pressure tests may be performed only with nitrogen or carbon dioxide if Group 1 refrigerants are used or only with nitrogen if the refrigerant is ammonia. The use of other gases requires the agreement of **TL**.

1.6 The refrigerating system is to be dried before the plant is filled with refrigerant.

2. Test Pressures

2.1 Components under refrigerant pressure

The test pressures to be used are specified in Table 1.5. According to the refrigerant used, HP is to be substituted by the design pressure on the high-pressure side and LP by the design pressure on the low-pressure side in accordance with Table 1.

(4) *National accident prevention regulations are to be complied with.*

L. Insulation of Pressure Vessels, Apparatus, Pipes, Valves and Fittings

1. Cold Insulation

1.1 All pressure vessels, apparatuses, pipes, valves and fittings whose operating temperatures may drop below the ambient temperature at the points where they are installed are to be provided with cold insulation. Items of plant which are accommodated in specially insulated refrigerating machinery spaces are exempted from this requirement.

1.2 Refrigerant and brine pipes which traverse uncooled spaces are to be insulated with special care and are to be installed so that they are protected from damage.

1.3 Assuming that the refrigerating installation has sufficient reserve capacity, cold insulation need not be fitted at control stations and control groups nor to apparatus, pipes, valves and fittings in refrigerated or air cooler spaces which are intended to serve exclusively for the refrigeration of the said spaces, provided that no damage can be caused there by dripping condensation water.

1.4 All air, sounding, thermometer and drain pipes in refrigerated and air-cooler spaces are to be adequately insulated.

1.5 Before being insulated, the items concerned are to be protected against corrosion.

1.6 Cold insulation is to be at least sufficiently thick to prevent the formation of condensation water on its surface at a maximum relative humidity of 90 %.

1.7 The insulation is to be free from discontinuities and its final layer must be given a vapourtight coating.

1.8 Insulation is to be protected at points where there is a danger of damage.

2. Heat Insulation

2.1 For insulation used to prevent accidental touching and fitted to pressure pipes between refrigerant compressor and condenser and to oil separators on the pressure side, see G.1.1.4.

2.2 To avoid premature refrigerant condensation, hot gas defrosting pipes are to be insulated over their entire length.

2.3 Components requiring insulation are to be protected against corrosion.

M. Equipment and Insulation of Refrigerated Spaces and Air Ducts

1. Equipment

1.1 The external boundary walls of refrigerated spaces are to be watertight and made of steel. If the use of other materials is envisaged, the agreement of **TL** is required.

Separately refrigerated spaces or groups of spaces are to be made airtight to prevent the taste, odour or ripening process from being adversely affected. All openings in the boundary walls of refrigerated holds are to be provided with airtight covers.

1.1.1 Air duct systems with built-in air coolers and circulating fans as well as couplings for attaching insulated containers must be airtight.

1.2 Manholes in the double bottom or in oil tank tops are to be surrounded with an oiltight coaming 100 mm in height.

1.3 Brine or refrigerant pipe penetrations through watertight bulkheads and decks must be of approved design. The pipes may not come into direct contact with bulkheads, ship's structure or other metal structural members. The fire resistance of the bulkheads and decks may not be impaired.

1.4 The clear openings of access trunkways and companion hatches leading to cargo or air cooler spaces may not measure less than 600 mm by 600 mm. Hinged hatch covers are to be protected against closing accidentally and must be capable of being re-opened by hand from inside.

Table 5 Test pressures for components under refrigerant pressure

Test	Item to be tested	Test pressure [bar] (1)	
		Hydraulic	Pneumatic
Prior to installation	Compressor (high-pressure side)	1,5 x HP	1 x HP
	Compressor (low-pressure side)	1,5 x LP	1 x LP
	Compressors with integrally cast cylinders and crankcase	1,5 x HP	1 x HP
	Motor compressors, assembled	—	1 x HP
	Refrigerant circulating pumps	1,5 x HP	1 x HP
	High-pressure vessels and apparatuses	1,5 x HP	1 x HP
	Low-pressure vessels and apparatuses	1,5 x LP	1 x LP
	Refrigerant valves and fittings (except automatic control valves)	1,5 x HP	1 x HP
Prior to start-up	Complete installations: High-pressure side Low-pressure side	 — —	 1 x HP 1 x LP

(1) *Where the low-pressure side of the installation can be subjected by operational switching to the pressure of the high-pressure side (e.g. for defrosting with hot gas), the vessels and equipment involved are to be designed and tested at the pressures prescribed for the high- pressure side.*

Table 6 Test pressure for components under cooling water or brine pressure

Test	Item to be tested	Hydraulic test pressure (1)
Prior to installation	Cooling water spaces of machines and equipment, cooling water pumps	1,5 $P_{e,zul}$, minimum 4 bar
	Vessels and equipment on the pressure side of brine pumps, brine pumps	1,5 $P_{e,zul}$, minimum 4 bar
	Vessels and equipment on the suction side of brine pumps	1,5 $P_{e,zul}$, minimum $P_{e,zul}$ + 0,2 bar
Prior to start-up	Cooling water lines, valves and fittings	1,5 $P_{e,zul}$, minimum 4 bar
	Brine pipelines, valves and fittings (prior to insulation)	1,5 $P_{e,zul}$, minimum 4 bar

(1) *$P_{e,zul}$ = maximum allowable working pressure [bar]*

1.5 Access doors or hinged hatch covers from companionways leading to cold rooms which are used for operational purposes, such as refrigerated spaces or air cooler spaces, refrigerated provision stores and also brine spaces must be capable of being opened from inside, irrespective of their closed condition.

These spaces are to be fitted with an alarm which must be connected to a station which is constantly monitored.

1.6 The supports of inspection gangways and refrigerated spaces are to be designed with sufficient strength to absorb the load exerted by the cargo.

1.7 Air ducts of refrigerated holds are to be fitted with fire flaps. Where the cargo makes this necessary, each refrigerated hold is to be provided with separately installed air intake and exhaust ducts.

1.8 Refrigerated spaces are to be provided with drains and/or bilge pumping facilities. In this connection, see **TL** Chapter 4, Machinery, Section 16, N.

1.9 For scuppers in the bulkhead deck, see **TL** Chapter 1, Hull, Section 16.

1.10 Circulating fans and air coolers installed in refrigerated or air cooler spaces must be accessible at all times. It must be possible to change fan impellers and drive motors even when the cargo spaces are fully loaded (see also H.1.)

1.11 Provision is to be made for heating the spaces should this be made necessary by the cargo or the route travelled.

2. Insulation

2.1 The inside surfaces of refrigerated spaces are to be adequately insulated. Thermal bridges are to be avoided. Structural members of the ship which may act as thermal bridges, e.g. decks, partitions and pillars, are to be fully insulated over a length of at least 1 m into the refrigerated space.

2.2 Divisions, bulkheads and decks separating refrigerated spaces at the same temperature need not be insulated. However, the requirement in 2.1 is to be complied with. Cladding is to be fitted to protect the cargo.

2.3 Insulating materials must be odourless and must not, as far as possible, absorb any moisture. Insulating materials, along with their cladding, must have highly flame-resistant properties to recognized standards. Polyurethane foams and insulating materials which have comparable flame-resistant properties may only be used with a metal or equivalent cladding.

The insulating materials used in refrigerated spaces must be approved by **TL**.

Where in-situ cellular plastic is used, the respective processing methods and also the processing recommendations issued by the manufacturer are to be submitted for examination. The behaviour of insulating material in fire is to be proven, on demand, by means of independent tests.

2.4 If timber is used in refrigerated cargo spaces, this is to be impregnated with, if possible odourless, media to prevent rotting and fire.

2.5 Insulation is to be permanently secured. Where insulation in the form of slabs is used, the edges of the slabs are to abut tightly against each other and where the slabs are laid in several layers the joints are to be staggered.

2.6 The insulation at manhole covers, bilge suctions and wells must be removable.

2.7 Refrigerated spaces should not lie adjacent to fuel or lubricating oil tanks. Where this cannot be avoided, a sufficiently wide gap is to be left between the vertical surfaces of such tanks and the insulation. This gap is to be provided with a drain leading to the bilge and with a vent pipe leading to the open air. The back of the insulation is to be protected against the penetration of moisture, e.g. by metal cladding.

2.8 The requirements set out in the previous paragraph apply in analogous manner to the tops of lubricating oil and fuel tanks. In the case of welded tank tops, the specified isolating gap may be dispensed with, provided that the top is covered with a well established oil proof coating without joints and of sufficient thickness.

2.9 For the insulation of piping in refrigerated spaces, see L.

2.10 The edges of insulated hatches and hatch covers, doors, bilge covers etc. are to be protected against damage.

2.11 At hatches, and for about 500 mm beyond, the deck insulation in lower holds is to be provided with a special protective covering. The same also applies to shaft tunnels.

2.12 Unless suitable deck material or aluminium gratings are provided as top covering, the insulation of the decks of refrigerated spaces is to be protected by battens measuring at least 50 mm by 50 mm in cross-section. The battens may take the form of removable gratings. Thinner battens may be used in refrigerated spaces in which the cargo carried is invariably suspended.

2.13 The insulation of the bulkheads of refrigerated spaces and of air ducts is to be suitably protected against damage. This protection is to be so designed that the air circulation is not affected.

2.14 Wherever applicable, the requirements set out in 2. apply analogously to air ducting systems for the connection of insulated containers.

3. Testing

3.1 The equipment and insulation of refrigerated spaces is to be tested under the supervision of **TL**. Compliance with the prescribed heat transfer values is to be demonstrated by performing the refrigeration test specified in P.2.

3.2 In order to simplify shipboard trials, air ducting systems with integral couplings and with built-in air coolers and air circulating fans which are completely fabricated at the works and which serve one container or one stack of containers are to be subjected to the following tests in the manufacturer's works under the supervision of **TL**:

3.2.1 Measurement of the heat transfer rate of each type by means of a heating test with a period of at least six hours in the steady state. The test procedure is to be agreed on with **TL**.

3.2.2 Measurement of the air leakage rate of each ducting system using an internal overpressure of 250 Pa above atmospheric.

3.2.3 Measurement of the air distribution in each ducting system (for every container air delivery connection).

3.2.4 Measurement of the power consumption of the air circulating fan for each ducting system.

3.2.5 Measurement of the air renewal rate for each ducting system.

N. Temperature Monitoring Equipment for Refrigerated Spaces and Refrigerated Containers

1. General

1.1 Suitably distributed and easily accessible thermometers are to be placed in each refrigerated space. At least one thermometer each is required before and after each air cooler.

1.2 Based on spaces of normal geometry and on the useful capacities shown, the following numbers of thermometers are to be fitted as a minimum:

- For space capacities up to approximately 300 m^3 = 2 thermometers
- For space capacities up to approximately 800 m^3 = 3 thermometers
- For space capacities over 800 m^3 = 4 thermometers

In determining the number of thermometers required, each individual refrigerated space is to be considered separately, even where several spaces are served by a single air cooler and the tween decks are not insulated.

1.3 In container refrigerating installations, each container is to be fitted with one thermometer each at the inlet and return connections for the air ducting system. Where cooling is applied by a common supply duct to one stack of containers, the individual thermometers for the supply air may be replaced by one thermometer to each stack, placed in the supply duct close to the air cooler.

1.4 Calibrated thermometers are to be used which give a reading of the accuracy required by the cargo.

1.5 Where thermometer tubes are fitted, these are required to have an inside diameter of at least 50 mm. If the thermometer tubes are to be operated from the free deck, screw connections and tubes are to be insulated from the deck plating. Where they pass through other spaces, the tubes are to be effectively insulated. They are to be so arranged that water cannot enter them.

2. Electrical Temperature Monitoring Equipment

2.1 Where temperatures are not monitored locally, electrical devices are to be fitted which comply both with the following requirements and **TL** Chapter 5, Electrical Installation.

2.2 In design and type of enclosure, all appliances and other system components must be compatible with the mechanical and climatic conditions attaching to their particular operating environments. So that they can be used in refrigerated cargo, mobile temperature sensors may be used in refrigerated holds. They are then to be fitted with connecting leads of sufficient length. The sensors are to be protected against mechanical damage.

2.3 At least two mutually independent temperature measuring systems with separate power supply are to be provided. The measuring points of each refrigerated space are to be evenly distributed on these temperature measuring systems.

Other systems may be approved provided that a representative temperature measurement can be ensured for each independently refrigerated space in the event of failure of any of the components inside the measuring chain. If this can only be ensured by replacing individual modules these are to be carried on board as spares. It must be possible to replace spare parts of this nature within a reasonable timescale and with- out any onboard programming being required. The failure of every component is to be signalled by an alarm.

2.4 The number of measuring points (sensors) in refrigerated spaces depends on the location and size of each space.

The requirements set out in 1.1 and 1.2 or 1.3 are to be complied with as a minimum. **(5)**

2.5 In air ducting systems for container refrigeration, the measuring points in the delivery and return air ducts are to be coupled to separate indicating instruments, unless provision is made for local measurement of at least the delivery air temperatures.

2.6 The measuring range of the systems must cover the entire anticipated temperature range plus an additional ± 5 K. Temperatures above or below the measuring range shall not have any harmful effect on the systems.

2.7 The accuracy of the temperature measurement and reading must be compatible with the requirements imposed by the sensitivity of the cargo with regard to temperature fluctuations. In the absence of special requirements, the following values are to be applied:

Maximum total error	
For fruit cargo	0,15 K (in range from + 10 °C to + 15 °C)
For deep-frozen cargo	0,5 K.

Exceptions are subject to **TL** special approval.

For analog readings, the scale calibration must be at least 10 mm/K for fruit cargo and at least 2,5 mm/K for deep-frozen cargo.

The temperature measurement may not be influenced by the duration of the duty cycle of the sensor.

(5) *Reference is made to additional national regulations, e.g. those of the U.S. Department of Agriculture (USDA).*

Changes in the resistance of the measuring leads due to temperature fluctuations between 0 °C and + 40 °C along the wire and/or fluctuations of ± 20 % in the measuring voltage may not cause the aforementioned total errors to be exceeded.

2.8 Measuring instruments and their illumination are to be so arranged that they can be reliably read without difficulty.

2.9 Wires and their installations must comply with **TL** Chapter 5, Electrical Installation. Waterproof distribution and junction boxes must be used.

2.10 Each temperature measuring system must be provided with its own power supply. The power supply systems are to be electrically independent of each other and of the shipboard supply system.

2.11 Where temperature measuring systems are supplied by their own power sources or via converters from the ship's network, provision must be made for simple switching to a stand-by power source or to a stand-by converter, e.g.:

- Where power is drawn from storage batteries, at least two batteries must be provided for each measuring system. These must be so connected that they can be switched alternately to charge and discharge.

- Where power is drawn from primary cells (dry cell batteries) or rechargeable batteries, these must be easily changeable.

- Where power is supplied from the ship's network via a converter, means must be provided for switching over the mains-connected appliances to a stand-by converter.

The mains unit of a temperature measuring system is not subject to these requirements (see O.1. Spare parts).

2.12 Instruments and appliances must be marked with their type and number.

2.13 The system and its individual components are to be subjected to a test in the manufacturer's works under the supervision of **TL**. **TL** may recognize this as a type-test for other installations of the same design.

The following shipboard tests are to be performed in each case:

Checking the system and the spare parts against the approved drawings and descriptions; operational test; inspection of the electrical installation.

O. Spare Parts and Protective Equipment

1. Spare Parts

1.1 To enable the operation of the refrigerating plant to be restored in the event of damage at sea, at least the spare parts listed in Table 7 are to be carried on board every ship.

1.2 Depending on the design and arrangement of the cargo refrigerating plant and the manufacturer's recommendations, a different range of spare parts may exceptionally be agreed between the ship owner and **TL**.

Where the stock of spare parts is based on special arrangements between the ship owner and **TL**, technical documentation is to be provided. A list of the spare parts is to be carried on the ship.

1.3 Spare parts for the electrical machines driving compressors, pumps and refrigerating space circulating fans are governed by **TL** Chapter 5, Electrical Installation.

Table 7 Spare parts

Scope of spare parts	Quantity
Compressor piston with piston rod and crank bearing of each type, ready for fitting	1
Set of piston rings of each type for 1 piston	1
Set of suction and delivery valves of each type for 1 cylinder	1
Shaft seal of each type ready for fitting	1
Of all expansion valves (including at least one of each type) for the refrigerant circuit	% 10
Suction and delivery valve stem of each type, with cone and seat, for the main shutoff valves of the compressors	1
Of each type of pressure switch for suction and pressure lines	1
Pressure gauge of each type	1
Of all thermometers for the refrigerating machinery and the refrigerated spaces, including at least two of each type	%10
Set of V-belts of each length, for 1 compressor	1
Oil sight glass of each type with gaskets	1
Fan impeller of each type	1
Of pipe plugs for steel condenser tubes	%2
Complete set of all rupture discs Packing jointing and sealing materials, a few lengths of the most widely used types of pipe, screw couplings, flanges nuts and bolts and device for topping up refrigerant charge	1
Detector for tracing leaks in the refrigerant system	1
Of all sensors for electrical remotely-operated thermometers, including at least 1 of each type	%10
Galvanometer for every five indicating instruments, including at least one of each type	1
Mains unit, including rectifier and transformer, where power is supplied from the ship's network; the electrolytes necessary for the operation of the batteries together with filling devices and meters, where power is drawn from batteries	1
Battery for battery power supply	1
For every module described in N.2.3	1

2. Protective equipment

The provision of gas masks, respirators, protective clothing etc. is subject to the accident prevention regulations in force.

P. Shipboard Testing

1. Operational Tests

The refrigerating installation is to be subjected to the following tests:

1.1 All compressors, pumps, fans, etc. are to be run simultaneously and demonstrated to **TL** Surveyor in all the anticipated speed ranges. It is to be proved that no unacceptable vibrations occur.

1.2 To test their functional efficiency, all compressors are to be operated both individually and together at various speeds of rotation and at different evaporation temperatures.

During the test they are to be connected to the condensers and evaporators in all the combinations possible in service.

1.3 The condensers are to be operated first with the normal cooling water pump and then with the stand-by cooling water pump. Operation of the cooling water supply when in dock, in accordance with I.4., is to be demonstrated.

1.4 Brine pumps are to be tested.

1.5 Circulating fans are to be operated at their specified service speeds - or with the prescribed blade settings in the case of variable-pitch fans - and the delivery rates measured. It is to be demonstrated to **TL** that the requisite rate of air renewal and uniform space ventilation are achieved.

1.6 The working of the defrosting devices for the air coolers is to be demonstrated.

1.7 The temperature variations of the cargo room sensors are to be determined and recorded (e.g. ice-water test).

2. Refrigeration Test for Cargo Refrigerating Installations

2.1 A refrigeration test is to be performed to demonstrate to **TL** that the degree of thermal insulation of the refrigerated spaces and the available refrigerating capacity of the refrigerating installation comply with the requirement set out in B.3. to B.6. The refrigeration test is to be performed by means of a heat balance test. The proof of performance is deemed to have been supplied if the heat transfer coefficient used as a basis in the calculation of the refrigeration demand is confirmed by **TL** analysis of the test results, taking into account the capacity of the refrigerating plant.

2.1.1 Where, in exceptional cases, only the thermal insulating effect of the refrigerated space insulation is to be tested, a twin radiation test (twin test) may be accepted as the method of testing.

The test procedure is to be agreed with **TL**.

2.2 The temperature in the refrigerated holds is to be lowered to the level corresponding to the refrigerated space temperature specified for the installation. For this purpose, the temperature difference between the ambient air and the refrigerated spaces should not, if possible, be less than 15 K.

2.3 In order to achieve thorough, uniform cooling of all parts, the refrigerated hold temperature is to be held constant at the later balance temperature for a period of at least ten hours. At the end of the cooling period, the refrigerating machinery must be in a steady operating condition.

2.4 The temperature measurements for the balance test are to be performed over a period of at least six hours during a time when the outside temperature is as constant as possible. Periods of strong solar radiation are to be avoided.

2.5 While measurements are being made, all machinery and equipment in use is to be maintained in a steady operating condition. During this time, no additional fresh air may be supplied to the refrigerated holds.

2.6 However, in order to establish the performance of the refrigerant compressors with sufficient accuracy, the balance test is to be carried out during the actual balance time using manual control.

2.7 The number of compressors needed to achieve the condition of balance is to be fixed so as to achieve continuous operation. If, under the test conditions, the capacity of even a single compressor is too great, the plant must be operated intermittently while recording the "on" time. The switching off of individual cylinders or rows of cylinders is not allowed.

2.8 The following measurements are to be carried out:

a) **Refrigerated spaces:** the temperatures in the refrigerated spaces and at the air coolers. In addition, the temperature curve is to be plotted by means of a temperature recorder. However, the test temperatures may not be read from the recorded graph.

b) **Ambient condition and other ship's spaces:** the temperatures of the ambient air and of the water are to be measured as are also the temperatures of other ship's spaces adjoining the refrigerated holds.

c) **Compressors:** pressure and temperature of the refrigerant on the suction and pressure sides, rotating speed of the compressors, and the power consumption of the drive motors. In the case of semi-hermetic motor compressors, measurement of the speed of rotation may be dispensed with.

d) **Condenser:** outlet temperatures of the refrigerant.

e) **Brine:** the temperature of the brine before and after the brine coolers, the pressure at the brine pump outlets, and the power consumption of the brine pumps.

f) **Circulating fans for the refrigerated spaces:** the power consumption of the fan motors.

During the balance time, recordings are to be made hourly, otherwise every two hours.

Care is to be taken to measure the ambient temperatures outside the refrigerated holds needed for the evaluation every hour over a period of 4 to 6 hours prior to the balancing time, depending on the insulation.

2.9 After the balance test, the following documents are to be submitted to **TL** Head Office:

a) A diagrammatic drawing of the ship and the refrigerated holds showing the points of temperature measurement.

b) A report on the test schedule including all the measured data and photocopies of the recorded temperature charts.

c) The ship's draught, fore and aft.

3. Refrigeration Test for Container Refrigerating Installations

3.1 **TL** may accept as an adequate ship- board trial an operational test analogous to that de- scribed in 1. subject to sufficient steady-state times for adjustments, provided that the following conditions are satisfied:

3.1.1 For the supply of cooling air to the containers exclusive use is made of air ducting systems in accordance with M.1.1.1 which have been satisfactorily tested in the manufacturer's works, as prescribed in M.3.2.

3.1.2 The manufacturer demonstrates by calculation the ample capacity of the refrigeration plant and the values applied in this calculation conform to **TL**'s experience with comparable systems.

3.1.3 An adequate number of containers is made available for the operational test.

3.2 If one of the conditions specified in 3.1 is not fulfilled, the refrigeration test is to be performed, in a manner analogous to that described in 2. Once for at least one empty container hold and once with a sufficient number of containers connected.

3.3 The documents specified in 2.9 b) and c) are to be submitted.