IRS

RULES FOR BUILDING AND CLASSING STEEL VESSELS

PART 12

CARGO REFRIGERATION INSTALLATIONS

DECEMBER 2013

INTERNATIONAL REGISTER OF SHIPPING
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CHANGES

CONTENTS

CHAPTER 1 GENERAL

CONTENTS

1.1. Class notation

1.1.1. An appropriate notation will be assigned to refrigerated cargo installations which conform to the requirements of this Chapter on an Owner's plea. The particulars of the installation and class notations assigned together will be entered in the Register Book. The class will be maintained so long as the installation is found, at the prescribed periodical surveys, to be in a fit and efficient condition and as per the requirements of the Rules. At the very first practical opportunity, any damage or breakdown which could affect the maintenance of class or temperature assigned should be reported to IRS.

1.1.2. **Vessels Built Under Survey**

Vessels proposed for the carriage of refrigerated cargoes, which conform to the requirements of the Rules, and which have been constructed, at the Owners request, under survey by the Surveyors, will be distinguished in the Record by one of the following notations, as appropriate, followed by the date of survey.

IRCC	Refrigerated Cargo Carrier
IRC (Hold No.)	Refrigerated Cargo Carrier – Some Holds Only
IRCCC	Refrigerated Cargo Container Carrier
IIRCC	Integral Refrigerated Container Carrier
IREBLT	Refrigerated Edible Bulk Liquid Tankers
IRFC	Refrigerated Fish Carrier

1.1.2.1. Vessels Carrying Cargo in Refrigerated Holds, **IRCC**

Where the cargo is carried in refrigerated holds, the Record will state the number and capacity of the insulated cargo spaces which have been examined, the description of the refrigeration machinery and the allied system, the character of the insulation, the minimum design temperature of each zone attainable with the maximum design ambient and sea water temperature.

In the presence of Surveyors, the conditions specified in the Record will be subject to validation by testing.

1.1.2.2. Vessels Carrying refrigerated Cargo in Some of the Cargo Hold(s), **IRC(Hold Number(s))**

Where onboard the vessel, facilities are provided for carriage of refrigerated cargo in some of the cargo hold(s), the Record will mention the refrigerated cargo hold number(s), the capacity, description of the refrigeration machinery, the characteristics of the insulation and the minimum design temperature attainable with the maximum design ambient and sea water temperatures.

In the presence of Surveyors, the conditions specified in the Record are subject to validation by testing.

1.1.2.3. Vessels Carrying Cargo in Refrigerated Containers of Porthole Type, **IRCCC**

Where cargo is transported in refrigerated containers, individually cooled by the shipboard refrigerated machinery and the allied systems and, where fitted, the associated temperature monitoring and control system, the Record will mention the number and average design thermal characteristics of the containers, the distribution system for refrigerating the individual containers (porthole type only) and description of the refrigeration machinery.

In the presence of Surveyors, the conditions specified in the Record are subject to validation by testing.

1.1.2.4. Vessels Carrying Cargo in Refrigerated Containers of Integral Type, ⌖ **IIRCC**

Where cargo is transported in refrigerated containers of plug-in or integral types with their own individually mounted refrigeration machinery, running on shipboard electrical power supply and in some situations the cooling water supply for the condensers and, where fitted, the associated temperature monitoring and control system, the Record will mention the total number of refrigerated containers onboard, the type of temperature monitoring and control system installed and the total design load in kW.

In the presence of Surveyors, the conditions specified in the Record are subject to validation by testing.

1.1.2.5. Vessels Carrying Edible Liquids in Bulk in Refrigerated Cargo Tanks, ⌖ **IREBLT**

Where edible products are transported in bulk in refrigerated cargo tanks cooled by their own shipboard refrigeration machinery and the allied system, the Record will state the cubic capacity and the maximum design pressure of the cargo tanks, the minimum permissible design temperature of the cargo, the maximum design ambient and sea water temperatures and a description of the refrigeration machinery.

In the presence of Surveyors, the conditions specified in the Record will be subject to validation by testing before issuance of the certificate.

1.1.2.6. Vessels Carrying Fish in the Refrigerated Cargo Holds, ⌖ **IRFC**

Where fish processing or fish storage vessels are laid with facilities for chilling, cooling, or freezing and/or storage in the refrigerated cargo holds cooled by their own shipboard refrigeration machinery and the associated system, the Record will mention the number and state capacity of the insulated cargo spaces which have been checked, the character of the insulation, the minimum design temperature of each space attainable with the maximum design ambient and sea water temperature and a description of the refrigeration machinery and the associated system.

In the presence of Surveyors, the conditions specified in the Record will be subject to validation by testing.

1.1.3. **Vessels Not Built Under Survey**

Vessels supposed to transport refrigerated cargoes, which have not been constructed under survey by the Surveyors, but which have been subsequently surveyed by IRS on Owners request, satisfactorily reported upon by the Surveyor, and which conform to the requirements of this Chapter, will be distinguished in the Record by one of the notations listed in 1.1.2, as appropriate, but the mark ⌖ signifying survey during construction will be omitted.

1.1.4. **Fruit Carrier, (F)**

At the request of the Owner or the builder, refrigerated cargo or container vessels proposed for transport of fruit which have been constructed and installed in conformation to the applicable requirements will be distinguished in the Record (F).

1.1.5. On application from an Owner, an alternative temperature notation being assigned to that appearing in the Register Book will be considered by IRS. It is not the responsibility of IRS that at which temperature the cargo is to be carried.

1.1.6. Installations constructed under Special Survey as per the requisites of this Section will be entitled for the distinguishing mark ++ before class notation. In other cases, the mark will not be assigned.

1.1.7. If the refrigerating plant is found to be capable of cooling down fruit in general or a catch of fish the symbol * may be added after the class notation.

1.1.8. IRS will give consideration to ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases, the class may comprise of service limitation or other restriction.

1.1.9. The requirements of Part 1 of the Rules, regarding withdrawal of class respectively, apply also to refrigerated cargo installations

1.2. Survey during construction

1.2.1. New installation proposed for classification is to be constructed and tested under Special Survey as per the terms and the requisites of this Chapter.

1.2.2. The materials used in the construction are to be manufactured and tested in terms with the requisites of Part 2. Materials for which provision is not made in Part 2 may be accepted, provided that they conform to an approved specification and such tests as may be considered necessary.

1.2.3. From the initiation of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to inspect the materials and workmanship and are to indicate at the earliest opportunity, and require the rectification of, any items not as per the Rules or the approved specifications and plans or any material, workmanship or arrangement found to be defective or unsatisfactory.

1.3. Definitions

1.3.1. **Direct Expansion**

It is a refrigeration system in which the refrigerant expansion occurs through direct absorption of heat from the primary medium to be cooled.

1.3.2. **Indirect Expansion**

It is a refrigeration system in which a secondary coolant is cooled by direct expansion of a primary refrigerant and is subsequently circulated to cool the medium which absorbs heat from the space to be cooled.

1.3.3. **Refrigerant**

The fluid used for heat transfer in a refrigeration system, which absorbs heat at a low temperature and low pressure of the fluid and rejects heat at a higher temperature and higher pressure of the fluid, usually involving a change of state of the fluid during the process.

1.3.4. **Secondary Coolant**

A liquid is so called as it is used for the transmission of heat, without changing its state, and having no flash point or a flash point above 66°C (150°F).

1.3.5. **Brine**

Brine is the term given to secondary coolants which are water solutions of sodium chloride, calcium chloride and magnesium chloride.

1.3.6. **Refrigerating Machinery Spaces**

Refrigerating Machinery Spaces are spaces dedicated for housing refrigerating machinery and the allied equipment / systems.

1.3.7. **Refrigeration Unit**

A Refrigeration Unit is the machinery comprising the compressor, the compressor's driving motor and a condenser, if fitted, independent of any other refrigeration machinery for provision stores or the air conditioning plant. In indirect refrigeration systems, the refrigeration unit also comprises of brine or other secondary coolant cooler.

1.3.8. **Refrigeration System**

A Refrigeration System comprises one or more refrigeration units, coupled together with the piping and ducting system as well as the equipment vital for cooling the cargo and maintaining it at the requisite temperature.

1.3.9. **Refrigerated Container**

A portable container designed and constructed to a recognized international standard and primarily proposed for transmitting refrigerated cargo, and which is adequately insulated to diminish heat loss through the boundary walls and made air tight through effective seals. Two types of refrigerated containers are referred to in this Chapter:

a) Port Hole Containers

These are the refrigerated containers wherein the cargo is cooled by cold air that is continuously circulated with the help of the flexible connections in the vessel's refrigeration system.

b) Integrated or Plug-in Containers

These are the refrigerated containers which are fitted with individual refrigeration unit either permanently installed or portable and supplied with an electrical power supply, and where required, cooling water supply from the vessel.

1.3.10. **Controlled Atmosphere**

For purposes of the Rules, a Controlled Atmosphere is where the oxygen concentration in the cargo space is reduced and the CO_2 concentration adjusted to the required levels by the introduction of high purity nitrogen or other suitable gas. Then, throughout the loaded voyage, oxygen and CO_2 concentrations within the cargo space are monitored and controlled.

1.3.11. **Automatic Pallet Loading/Unloading System**

An Automatic Pallet Loading/Unloading System is one that is supposed to load from the quay side, stows within the hold, and unloads pallets. A stacking system is fitted within the holds, comprising of conveyors, transporters or other similar means together with the control equipment and lifting appliances for use to maneuver the pallets automatically.

1.3.12. **Automatic or Semi-automatic Side Loading System**

An Automatic or Semi-Automatic Side Loading System is one that is supposed to load from the quay side and deliver the pallets to the appropriate refrigerated hold using hoists, conveyors, cranes or other similar means together with the control equipment for use in maneuvering the pallets semi-automatically or automatically.

1.3.13. **Refrigerated Edible Bulk Liquid Tankers**

Tankers transmitting refrigerated edible bulk liquid which is required to be maintained at a pre-specified temperature with help of the refrigeration system fitted on board the vessel.

1.3.14. **Cargo Containment System**

The Cargo Containment System for the transportation of edible bulk liquid cargoes referred to in Ch-11, Sec 11, 11.4 may comprise of cargo tanks as given below:

a) Integral Tanks

Integral Tanks refers to a cargo containment envelope which forms part of ship's hull structure and which may be stressed in the manner and by the same loads which stress the neighboring hull structure and which is normally vital to the structural completeness of the ship's hull.

b) Independent Tank

Independent Tank refers to a cargo containment envelope which is not the neighboring hull structure or part of it.

c) Gravity Tank

Gravity Tank refers to a tank that has a design pressure not greater than 0.7 bar gauge at the top it. It may either be an independent tank or an integral tank.

d) Pressure Tank

Pressure Tank refers to a tank with a design pressure greater than 0.7 bar gauge. It is to be an independent tank.

1.3.15. **Refrigerated Fish Carrier**

Fishing vessels, fish processing vessels and mother ships of fishing fleet which are laid with facilities for freezing fish and its products are referred to as the refrigerated fish carrier.

CHAPTER 2 PLANS AND DATA TO BE SUBMITTED

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2.1. Hull Construction Drawings

General Arrangement
Capacity Plan
Midship Section
Framing Plan
Scantling profile and decks
Bottom Construction, floors, girders, etc.
Inner bottom plating
Shell expansion
Deck plans
Pillars and girders
Watertight and deep tank bulkheads
Miscellaneous non-tight bulkheads used as structural supports
Shaft tunnel
Machinery casings, engine and main auxiliary foundations
Fore end construction
Aft end construction
Stern Frame and rudder
Shaft struts
Superstructures and deckhouses and their closing appliances
Hatches and hatch closing arrangements
Side Shell Door – Construction and locking and sealing arrangements
Ventilation systems on weather decks
Anchor handling arrangements
Foundation structure for cranes and other lifting devices
Plan of hull showing steel grades
Cargo securing manual
For stability review:

- Lines and body plan
- Hydrostatic curves
- Cross curves
- Stability information

Additional plans for container ships

- Stowage arrangement of containers including stacking loads
- Location of container supports and their connection to hull

2.2. Refrigerated cargo spaces

Details of insulation installation including density, *K* factor, etc.
Details of the fixing arrangements for the load bearing supports of the insulation and linings and of all other insulation support fittings embedded by the insulation.
Details of the weld designs for the attachment of the fittings to the vessel's structure
Proposed arrangements for fixing insulation to the vessel's structure
Details of the fasteners used for supporting pipework embedded in insulation.
Cargo space heating arrangements (where fitted)
Corrosion protection of the steel structure
Temperature gradient calculations

2.3. Refrigeration systems and refrigeration machinery spaces

Design pressure and temperature of the refrigeration system
Details of the refrigerant and secondary coolant
Heat-load calculations and refrigeration capacity, including rate of ventilation of the cargo spaces, where applicable.

Details of the compressors, prime-mover drive, condensers, receivers, pumps, thermostatic expansion valves, oil recovery equipment, filters and dryers, evaporators and other pressure vessels and heat exchangers
Piping diagrams of refrigerant, brine and condenser cooling system
Details of the air-coolers, including corrosion protection
General arrangement of refrigeration units, indicating location
Ventilation details of refrigeration machinery spaces, including ventilation rates
Capacity calculations for all of the pressure vessel safety relief valves
Details of the safety relief devices discharge piping, including design calculations
Corrosion protection of the refrigerant and brine pipes
Cargo hold defrosting arrangements
Drainage and bilge pumping arrangements
Location and types of portable fire extinguishers

Additional plans and data for the ammonia refrigeration system:

- Access arrangement to the refrigeration machinery spaces
- Details of the emergency ventilation system
- Details of the emergency drainage system
- Details of the sprinkler system and water screen devices
- Fixed ammonia detection system
- Details of the personnel safety equipment

2.4. Electrical systems

Electrical one line wiring diagram for refrigeration machinery
Power supply and distribution
Arrangements of electrical equipment and cable way in refrigerating machinery spaces and refrigerated cargo holds including cable penetrations of insulated bulkheads and decks
Arrangements of thermometers in refrigerated cargo spaces
Heat tracing arrangements, where fitted

2.5. Instrumentation, control and mentoring systems

Control and monitoring panels for refrigerating machinery including schematic diagrams, function description, construction plans and outline view
Operational description of automatic or remote control and monitoring systems including a list of alarms and displays
Computer-based systems are to include a block diagram showing system configuration including interface, description of hardware specifications, fail safe features and power supply
Control and monitoring
Temperature measuring system
Refrigerant leakage detection and alarm system
O_2 and CO_2 content measuring system
Ammonia vapor detection and alarm system

2.6. Cargo handling equipment

2.6.1. Cranes

Where cranes are fitted, the resulting loads on the structure are to be indicated in the plans. The total crane weight including hook load and the arrangement of wheels and rails etc are to be submitted for approval of the supporting structure. Certification of cranes would be specially considered.

2.6.2. **Derrick and Booms**

The drawing submittal is to be in accordance with Part-13, Chapter-2, Sec-2.

2.6.3. **Cargo Elevators**

Where elevators are fitted, the resulting loads on the structure are to be indicated in the plans. The total weight of elevators and the arrangement of same are to be submitted for approval of the supporting structure. Certification of elevators would be specially considered.

2.7. Automatic and semi-automatic side loading system

2.7.1. **Structural Plans**

Location of guide supports
Stowage arrangement for pallets including stacking loads
Guide arrangement, scantlings, material grades and details
Details of the structural connections to the hull (including insulation)
Track, conveyors, foundation and support structure for the lifting devices
Deck and Side shell openings, framing and reinforcement details, details of the closing appliances, locking and sealing arrangements.
Pallet securing arrangement and scantling plan.
Deck openings, framing and closing appliance.
Deckhouse
Operating manual

2.7.2. **Electrical, Automation and Control**

Rated load, rated speed and operating condition
Electric power installation including motor, control, wiring and protective devices
Details of controls, interlock, safety devices and brakes
Control and monitoring panels including schematic diagrams, function description, construction plans and outline view
Hydraulic and control piping system details
Arrangements for emergency operations

2.8. Refrigerated Porthole Cargo Container System

Number and overall heat transfer rates of insulated cargo containers to be individually cooled by shipboard refrigeration system
Space heating arrangements for cargo cells
Details of the air ducting
Air circulation rates
Details of the flexible coupling, together with means of actuation

2.9. Refrigerated Internal Cargo Container System

Cooling water arrangements
Air freshening (ventilation) arrangements for cargo cells

2.10. Controlled Atmosphere

Capacity calculation for the nitrogen plant
Arrangements for controlling the CO_2 in cargo hold
Details of CO_2 and ethylene scrubber

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

2.11. Refrigerated Edible Bulk Liquid Tankers

Design specific gravity of cargo
Cargo tanks arrangements and details
Cargo tank construction and material details
Cargo tank foundations/supports (non-integral tanks)
Details of cargo tank coatings
Cargo pumping arrangements
Cargo tank refrigeration system
Cargo tank washing system
Nitrogen injection system for cargo tanks (where fitted)
Details of inert gas system, if provided

2.12. Refrigerated Fish Carriers

Details of the hull reinforcement (where provided)
Details of the cargo spaces, as per 2.2
Details of the refrigeration system and refrigeration machinery spaces, as per 2.3
Details of the refrigerated sea water (RSW) tanks
Details of the arrangement for protection of the Ammonia piping in cargo hold (direct expansion systems)

2.13. Onboard Tests and Trials

Test schedules for the tests and commissioning trials referred to in Chapter 13.

CHAPTER 3 REFRIGERATING PLANT

CONTENTS

3.1. General

3.1.1. The location of the refrigeration units and associated equipment such as coolers, pumps, cooling fans and motors, etc., is to be so located that ample space is available for easy access to them during repair and maintenance.

3.1.2. In general, the refrigeration units for cargo refrigeration are to be completely independent of any refrigerating machinery related to air conditioning plants or provision refrigeration installations. A combined system, on an individual basis, will be subject to special consideration.

3.1.3. An effective defrosting system well suited to service conditions and cargo carried is to be installed.

3.2. Design considerations

3.2.1. Design Pressures

3.2.1.1. The maximum allowable working pressure at which the system can be used is the design pressure. To not let the design pressure exceed beyond a permissible limit, relief valves in any part of the system are to be set such that the design pressure of the system is not exceeded.

3.2.1.2. The system is to be designed such that under all standstill and normal operating conditions, design pressure is not exceeded beyond a limit.

3.2.1.3. Generally, the design pressure on the high pressure side of the system is to be such that it is not less than the pressure corresponding to the condensing temperature of the refrigerant used, e.g. saturated pressure at 55°C (130°F) for refrigerants with negligible or zero glide. The bubble point pressure as indicated with an asterisk in 3.2.1.6 is to be used for zeotropic blends with significant glide.

3.2.1.4. The design pressure of the low pressure side of the system is to be such that it is not less than the pressure corresponding to the evaporating temperature of the refrigerant used at the discharge from the expansion valve, e.g. saturated vapor pressure at 45°C (113°F) for refrigerants with negligible or zero glide. The bubble point pressure as indicated with an asterisk in 3.2.1.6 is to be used for zeotropic blends with significant glide.

3.2.1.5. Where the method adopted for defrosting is circulating hot refrigerant gas, the design pressure on the low pressure side is to be exactly similar to that on the high pressure side.

3.2.1.6. The minimum design pressure for the refrigerants listed is to be as given in Table 3.1

Table 3.1: Minimum Design Pressure for Refrigerants

Refrigerant	High pressure side bar (kgf/cm^2, psi)	Low pressure side bar (kgf/cm^2, psi)
R 22	20.5 (20.9, 295)	17.1 (17.4, 250)
R 717	22.4 (22.8, 325)	17.9 (18.3, 260)
R 134a	13.7 (14.0, 200)	10.5 (10.7, 150)
R 404a*	25.0 (25.5, 365)	19.8 (20.2, 285)
R 407a*	25.2 (25.7, 365)	19.8 (20.2, 285)
R 407b*	26.5 (27.0, 385)	20.9 (21.3, 305)
R 407c*	23.9 (24.4, 345)	18.8 (19.2, 275)
R 410a	32.8 (33.4, 475)	25.9 (26.4, 285)
R 410b	32.5 (33.1, 471)	25.7 (26.2, 375)
R 507	25.4 (25.9, 370)	19.9 (20.3, 290)

3.2.2. **Capacity**

3.2.2.1. General

a) Minimum two refrigeration units are to be given. The aggregate capacity of the units is to be adequate to deal properly with the cargo as received aboard. The ambient conditions for determining the required capacity are to be based on the conditions as given below:

Air temperature	35°C (95°F)
Sea water temperature	32°C (90°F)
Relative humidity	75%

Alternative conditions are specially considered upon Owners and/or Builders plea, in case the vessel is proposed to operate in regions where the temperature and the relative humidity other than those given above are faced.

b) The capacity of the refrigerating machinery is to be selected keeping in mind their purpose and service conditions. Where pertinent, allowance is to be made for heat generated by air circulation fans, produced by cargo, heat transmission via insulation, introduction of fresh air and heat input from other sources namely pipes, insulation, ducts, tank tops, steel structure, etc.

c) To compensate for the higher wear and tear of blown foam insulation over the life of the installation, the calculated transmission heat (calculated on the basis of the rated insulation performance), is to be increased by 10%, before its inclusion in the capacity calculations.

d) The capacity of the units will be subject to special consideration, where refrigerated spaces are served by autonomous and distinct refrigeration units.

3.2.2.2. Fruit Carriers

a) For the purposes of calculations, in all the loaded refrigerated cargo spaces, under the conditions specified in 3.2.2.1, the aggregate capacity of the refrigeration system is to be such that the return air temperature can be simultaneously reduced to a temperature 2°C (1°F) higher than the requisite steady state delivery air temperature in between 24 to 36 hours.

b) When the vessel is likely to operate under conditions other than those stated in 3.2.2.1 (a), a cool down period greater than that stated in (a) above will be specially considered or even an alternative cool down period can be agreed upon between Owners and designers/builders.

c) If one of the refrigeration units becomes non-operational, the capacity of the remaining unit(s) is to be adequate to achieve and maintain the requisite delivered air steady state temperature when operating under the design conditions mentioned in 3.2.2.1.

3.2.2.3. Refrigerated Cargo Vessels other than Fruit Carriers

a) For the purposes of calculations, the total aggregate capacity of the refrigeration system is to be such that minimum design temperature in all refrigerated cargo holds can be attained under maximum loads with ambient conditions, as applicable and specified in 3.2.2.1.

b) The capacity of the refrigeration system is to be adequate to maintain the minimum design temperature in all refrigerated cargo spaces, under the conditions specified in 3.2.2.1, as applicable, with one of the units in standby condition.

3.2.2.4. Fish Processing Vessels

The aggregate capacity of the refrigeration system is to be as per the terms laid in 3.2.2.3.

3.3. Refrigerants and secondary coolants

3.3.1. Those refrigerants which are listed under 3.2.1.6 may be used in the refrigeration system of a refrigerated cargo vessel classed with IRS.

3.3.2. Other refrigerants will be allowed by IRS to be used, subject to approval of the chemical properties, including flammability, toxicity and compliance.

3.3.3. Where a refrigerant in a refrigeration system is proposed for replacement onboard existing vessels classed under IRS Class, their use will be subject to the following:

3.3.3.1. Where substituted refrigerant operates at pressures greater than the system's original design pressure, it is required that the details showing the method used are submitted, for instance, calculations followed by hydrostatic tests, so that it is ensured that the existing system is well integrated and intact to withstand higher pressures under all operating and stand still conditions.

3.3.3.2. For those substitute refrigerants which incorporate a flammable component, measures are to be taken to ascertain that air cannot enter in the system.

3.3.3.3. The lubricating oil is to be soluble with the substitute refrigerant.

3.3.3.4. For hygroscopic lubricating oils, the refrigeration system in use is to be effectively dehydrated before charging.

3.3.3.5. In those systems in which chlorinated refrigerants and mineral oils were previously contained, poly-glycol lubricating oils should not be used.

3.3.3.6. The thermal stability of the lubricating oil and the discharge gas temperature is to be compatible.

3.3.3.7. The capacity of the pressure relief devices and the diameter and length of the discharge pipes are to conform to 3.9.8, 3.9.9 and 3.9.10.

3.3.3.8. The materials used in the existing system are to be compatible with the substitute refrigerant.

3.3.3.9. A refrigerant leakage detection system conforming to Ch-8, 8.5 is to be provided as per the terms laid in Ch-8, 8.5.1.

3.3.4. In shipboard refrigeration systems, hydrocarbons such as propane, butane, pentane or other similar flammable products are not allowed to be used as refrigerants.

3.3.5. Various administrations do not permit the use of CFCs as refrigerants in shipboard refrigeration systems.

3.3.6. Solutions of calcium chloride (CaCl), sodium chloride (NaCl), magnesium chloride (MgCl) and water, commonly referred to as brine, may be used as secondary coolant in shipboard refrigeration systems. However, other substances will be considered as secondary refrigerants only if the flash point of the substance used is greater than 66°C (150°F).

3.3.7. The concentration of brine is to be so maintained that it suits the evaporating temperature.

3.3.8. A nationally recognized agency or other similar authorized body approves the refrigerant storage cylinders.

3.4. Materials and fabrication

3.4.1. Materials are to meet the applicable requirements in Part 2, Chapter 2 and Part 6, as applicable.

3.4.2. Materials used for air coolers are to be corrosion-resistant or, alternatively, safeguarded by galvanizing of the external surfaces exposed to the airflow.

3.4.3. Ferrous materials for refrigerant piping, valves and fittings with an intended service temperature below - 18°C (0°F) are to conform to the requirements of Part 2, Ch-2, Sec-18, or with other approved specifications, except that:

3.4.3.1. For austenitic stainless steel, impact testing will not be required
3.4.3.2. For nut and bolt materials, impact testing will not be required
3.4.3.3. Impact testing will not be required if the intended service temperature is not below - 29°C (-20°F), and provided the maximum fiber stress is not more than 40% of the allowable stress indicated in Part 6, Table 10.3.3 or Table 8.2.2.

3.4.4. Seamless copper piping and seamless red brass piping, manufactured as per the requirements of Part-2, Ch-4, Sec-2 & Sec-5, and seamless or welded copper-nickel piping will be acceptable without impact testing.

3.4.5. Material for crankshafts, cylinders and cylinder covers, connecting rods, housings, rotors and rotor casings of reciprocating and rotary compressors, as applicable, is to be as per the applicable requirements of this Section and Part 2, Chapter 2. Materials conforming to other recognized standards will be considered.

3.4.6. Synthetic materials, such as neoprene, chloroprene, etc., may be used for gaskets, seals and packing in halocarbon refrigerant systems. Natural rubber is not to be used for applications in contact with the refrigerant.

3.4.7. Where the intended service temperature is below -18°C (0°F), ferritic steel plating used for the fabrication of refrigerant liquids receivers or other low-temperature pressure vessels is to be as per Part 8 – C, Ch-3, Table-3.2.3. Provisions for exemptions to the toughness / impact testing for low-stress applications in 3.4.3 may be applied to the receivers and pressure vessels.

3.4.8. For refrigerant service, cast iron pipe is not to be used.

3.4.9. The material of pipes, valves and fittings is to be in terms with Part 2, Chapter 2 and is to be compatible with the refrigerant and, where applicable, the secondary coolant. For service where the fluid is a strong electrolyte such as brine, the materials used within the same system are to be compatible in terms of galvanic potential. In general, fabrication is to be in terms with Part-2, Ch-3, Sec-3, 3.5.3 and the following:

3.4.9.1. Ammonia System

Piping is to be black steel (non-galvanized). Seamless pipes and welded pipes are acceptable for use in Ammonia systems.

3.4.9.2. Halocarbon System

Welded or seamless brass, copper or copper-alloy pipes may be used in halocarbon systems. Piping is to be welded or brazed and pipe connections made are to be either welded or through brazed flanges. Soldering is not allowed.

Connections to valves, castings, expansion joints, spool pieces and other similar fittings is to be by welding, brazing or by use of flanges.

Magnesium alloys are not to be used where they would be in contact with any halogenated refrigerants, e.g., R22, R134a, etc.

Note: All materials used in refrigerating equipment and systems are to be suitable for use with the selected refrigerants. This includes joints, sealing materials and lubricants. For example, the following materials and refrigerants are not to be combined:

- Copper with ammonia.
- Magnesium with fluorinated hydrocarbons.
- Zinc with ammonia or fluorinated hydrocarbons.

3.4.10. For use in liquid to vapor/gas heat transfer components, finned piping is acceptable.

3.4.11. Materials used for construction of pump components and which are exposed to the medium being circulated are to be suitable to bear the effect of that medium.

3.5. Location and access

3.5.1. The refrigeration machinery may be placed in the main/auxiliary machinery spaces or in an absolutely segregated dedicated space.

3.5.2. Spaces containing refrigerant storage cylinders and refrigeration machinery are not to have direct access to accommodation spaces. Doors are required to open outwards and those not leading into the open deck directly are to be self-closing.

3.5.3. Refrigerant storage cylinders are to be adequately secured and placed in the space containing the refrigeration machinery or a dedicated space which is independently, naturally ventilated. Means for closing the vent openings from outside the dedicated space are to be given.

3.5.4. Air coolers and fans are to be so placed that will enable easy access for the repair, maintenance and replacement of equipment with the refrigerated cargo spaces fully loaded.

3.6. Ventilation of Refrigeration Machinery Space

3.6.1. Spaces containing refrigerating machinery are to be ventilated with the help of mechanical ventilation. The ventilation is to be capable of providing at least 30 air changes per hour.

3.6.2. The ventilation system serving the accommodation spaces is not to be connected to ventilation ducting of spaces containing refrigerating machinery and the ventilation exhaust is to be led to the weather independently from other ventilation ducting.

3.6.3. The exhaust air ducts are to be air tight and the exhaust outlet is to be so placed that recirculation to other enclosed spaces is prevented.

3.6.4. Means for stopping the ventilation fans and closing the ventilation openings from outside the refrigerated machinery spaces is to be provided.

3.7. Compressors

3.7.1. The crankcase of trunk piston compressors and rotor casing of rotary compressors are to be designed to bear a pressure equal to the maximum design pressure of the high pressure side of the system.

3.7.2. Water cooled compressors are to be designed for a water temperature of at least 32°C (90°F). Air-cooled compressors are to be designed for an air temperature of at least 45°C (113°F).

3.7.3. Compressors of the positive displacement type over 10 kW (13.4 hp) are to be fitted with a relief valve or a bursting disc so arranged that the discharge is led from the high pressure side to the low pressure side in the event that the discharge valve is inadvertently closed. The capacity of the pressure relief device is to be adequate enough to accommodate the discharge from the compressor when operating at full load at the maximum possible suction pressure for the refrigerant used. Alternatively, discharge may be led to deck, provided the outlets are located as per 3.4.6.

3.7.4. Compressor vibration resulting from gas pressure pulses and inertia forces are to be kept in mind while designing the compressor design and mounting arrangement. Acceptable mounting arrangements comprises of resilient rubber mounts, springs, etc.

3.7.5. The safety devices that automatically stop the compressor shall be there in it, as per Table 8.2.

3.7.6. All compressors are to be equipped with gauges as mentioned in Table 8.2.

3.8. Pressure Vessels and Heat Exchangers

3.8.1. **General**

As per Part 6, Chapter 10, pressure vessels and heat exchangers under refrigerant pressure are to be constructed.

3.8.2. **Oil Recovery Equipment**

Oil separators with automatic drains are to be given upstream of the evaporator. For compressors which have oil separators and gas inter coolers are also to be provided between inter cooler and low stage discharge. Suitable arrangements for recovering oil from surge pots are to be there as well.

3.8.3. **Refrigerant Filters and Dryers**

3.8.3.1. Filters are to be there in the liquid line upstream of the expansion valves and in the gas line on the suction side of the compressor.

3.8.3.2. Where water solubility in the refrigerant is low, dryers are to be provided to maintain the water vapor content below the value at which free water will occur in the low pressure side of the system. The dryers are to be sited upstream of the expansion valves.

3.8.4. **Liquid Receivers**

3.8.4.1. The refrigerating system is to be given a liquid receiver with shut off valves so arranged that they accept and are capable of holding the whole of the refrigerant charge of the refrigerating units during servicing or repairs. Where an individual receiver is fitted in each refrigerating unit, it should have adequate capacity to hold the charge from that unit.

3.8.4.2. Gauge glasses of the flat glass type having approved self-closing valves at each end are to be fitted in the receivers. Tubular type gauge glasses will be considered, provided they are fitted with approved self-closing valves at each end and are safeguarded from mechanical damage.

3.8.5. **Expansion Valves**

Expansion valves are to be appropriate to attain the required temperature for the refrigerant used.

3.8.6. **Evaporators**

Flooded type evaporators are to be provided with arrangements for recovering oil.

3.8.7. **Brine Heater**

Where an auxiliary boiler is used for heating brine, the capacity of the boiler is to be adequate to ascertain that heating of all refrigerated cargo spaces can be executed simultaneously, while also supplying other shipboard consumers under normal operating conditions.

3.9. Safety Relief Devices

3.9.1. The pressure relief devices provided in each refrigerant system are set to relieve at a pressure not more than the design pressure. Where relief valves are built-in, they are to be of such type that back pressure does not affect them.

3.9.2. No means for isolation of pressure relief devices are to be provided from the part of the system they are securing. However, the isolation arrangement described in 3.9.4 will be acceptable, where over pressure protection is achieved via dual pressure relief devices.

3.9.3. Pressure vessels containing liquid refrigerant and which may be isolated from the refrigeration system are to be secured with help of pressure relief valve or bursting disc set to relieve at a pressure not greater than the design pressure.

3.9.4. Pressure vessels with an internal *g*ross volume of 0.285 m^3 (10 ft^3) or greater are to use dual pressure relief valves or two bursting discs, or a combination thereof. These devices are to be fitted with a three-way valve to allow maintenance of either of the two relief devices without isolating the other. A single pressure relief valve may be used where pressure relief is to the low pressure side of the refrigeration system.

3.9.5. Pressure relief valves are to be provided in those sections of piping that can be isolated in a liquid full condition so as to bear excessive pressure due to temperature rise.

3.9.6. Discharge from pressure relief devices is to be led directly to the weather or the low pressure side of the refrigerant system for subsequent relief to the weather. The discharge outlet from these relief devices is to be led away from ventilation inlets and openings. Prevention against the entrance of dirt, water and debris is to be provided.

3.9.7. When the discharge from a pressure relief valve is led to the weather, further protection against loss of refrigerant through leakage may be provided with helps of leak detectors located between the outlet and the relief valve.

3.9.8. The minimum required discharge capacity of the pressure relief device, in terms of air flow, for each pressure vessel is to be determined by the following formula:

$$C = f \times D \times L_{pv}$$

Where:
C = Minimum required discharge capacity of the pressure relief device, in terms of air flow, kg/s (pounds per minute).
L_{pv} = Length of the pressure vessel, in m (ft).
D = Outside diameter of the pressure vessel, in m (ft).
f = Factor applicable to type of refrigerant. The values for f of the more common refrigerants are listed in the Table 3.2.

Table 3.2: Value of f and f*

Refrigerant	f metric (US units)	f * metric (US units)
R 22	0.131 (1.6)	-
R 134a	0.131 (1.6)	-
R 404a	0.18 (2.2)	-
R 407a	-	0.163 (2.0)
R 407b	-	0.203 (2.5)
R 407c	0.131 (1.6)	-
R 410a	-	0.163 (2.0)
R 410b	0.197 (2.4)	-
R 507	-	0.203 (2.5)
R 717	0.041 (0.5)	-
f * - Factor proposed and under consideration.		

3.9.9. The internal diameter of the discharge pipe from the pressure relief device is not to be less than the outlet of that device. The internal diameter of a common discharge line serving two or more pressure relief devices which may discharge simultaneously is to be based upon the sum of their outlet areas with due allowance for the pressure drop in all downstream sections.

3.9.10. The maximum length of the discharge pipe serving a pressure relief device is to be determined by the following formula:

$$L_{dp} = \frac{F\, P^2\, d^5}{C_r{}^2}$$

Where:
F = 1.95×10^{-10} (1.88×10^{-10}, 0.5625)
d = Internal diameter of discharge pipe, mm (in.)
P = {Set pressure of relief device × 1.1} + 1.0 bar (1.0 kgf /cm^2, 14.7 psi)
L_{dp} = Length of the discharge pipe, m (ft)
C_r = Rated discharge capacity of pressure relief device, in terms of air flow, kg/s (pounds per minute).

3.10. Air Coolers

3.10.1. Upon the total heat load and service conditions specified in 3.2.2, and the air circulation rates specified in Ch-4, 4.5, the design of the air cooler coils/cooling grids is to be based.

3.10.2. The refrigeration system is to be designed such that under steady state conditions the dehydration of fruit cargo and the frosting of air cooler coils/cooling grids is minimized, and the inlet temperature of the refrigerant or secondary coolant circulating in the air cooler coils/cooling grids is not more than 5°C (9°F) below the delivery air temperature for fruit cargoes and 10°C (18°F) below the return air temperature for frozen cargoes.

3.10.3. For each refrigerated cargo space over 300 m^3 (10,600 ft^3) cooled by air coolers, the air cooler coils are to be separated into at least two independent sections so that any one of them may be isolated without affecting the operation of the others. Alternatively, at least two independent air coolers are to be fitted.

3.10.4. A defrosting system is to be installed.

3.11. Cooling Grids

The cooling grids are to comprise of at least two independent sections so that any one of them may be isolated without affecting operation of the others, for each refrigerated cargo space over 300 m^3 (10,600 ft^3) cooled by cooling grids.

3.12. Piping Systems

3.12.1. Design Considerations

3.12.1.1. As per the requirements of Part 6, Ch-8 & Ch-9, pipes, valves and fittings are to be fitted.

3.12.1.2. The design of the refrigerant piping is to such that it resists collapse when subjected to the drying procedure detailed in Ch-13, 13.1.2.

3.12.1.3. An adequate net liquid column above the pump centerline is to be there in the refrigerant pump where liquid refrigerant is being pumped near its saturation pressure, so as to provide the requisite pressure that causes liquid flow into the pump suction without flashing.

3.12.1.4. There arrangements are to be provided for preventing slugs of oil or liquid refrigerant from entering the compressor suction. With the help of appropriately satisfactory means, any collected liquid may be returned to the system.

3.12.1.5. Deck penetrations and bulkheads of those refrigerant/secondary coolant pipes whose working temperature is below the normal ambient temperature are to be constructed so as to prevent the direct contact between the pipes and the steel members of the structure of the ship's.

3.12.1.6. Where pumps are used to circulate the liquid refrigerant through the system, arrangement of a dedicated, readily interchangeable standby pump without reduction incapacity that can replace it is to be provided.

3.12.1.7. Where pumps are used to circulate the secondary coolant through the system, arrangement of a dedicated, readily interchangeable standby pump, without reduction in capacity that can replace it is to be provided.

3.12.1.8. Preferably, brine tanks are to be of a closed type and have ventilating pipes that lead to the weather away from ventilation inlets and openings to accommodation spaces. Wire gauze is to be integrated in the ventilating pipe outlets.

3.12.1.9. Where open type brine tanks are fitted, to prevent accumulation of objectionable vapor, the compartments in which they are located are to be properly ventilated.

3.12.1.10. Where essentially required, the refrigeration units may be interconnected on the discharge and/or suction side to aid operation of the individual compressors with each condenser and, where applicable, with each brine cooler.

3.12.2. **Corrosion Prevention and Insulation**

3.12.2.1. All refrigerant/secondary coolant pipes with working temperatures below ambient temperature and those located within refrigerated chambers or embedded in the insulation are to be secured externally against corrosion. With the help of other equally effective methods approved by IRS, steel pipes are to be galvanized on the outside or protected against corrosion.

3.12.2.2. Brine pipes are not to be galvanized internally.

3.12.2.3. The pipes which are welded or threaded in place, such as at flange and pipe connections, are to have their corrosion protection reinstated by an approved method.

3.12.2.4. All pipes indicated in 3.12.2 and the valves and fittings whose working temperature is below the normal ambient temperature are to be effectively insulated. The insulation is to be so thick so as to prevent the formation of moisture on the pipe surface at 90% relative humidity. The insulation is to be free of discontinuities and must be secured where there is a risk of damage, and its final layer must be resistant to moisture penetration.

3.12.3. **Valves and Fittings**

3.12.3.1. Ball valves, gate valves and plug cocks are not to be fitted in the liquid refrigerant circuit unless the expansion of liquid trapped in the valve cavities when the valve or cock is closed is taken into consideration.

3.12.3.2. Removable sealing caps or other alternative means to retain any leakage that may pass through valve glands and seals are to be fitted in valves in the refrigerant circuit. However, remote controlled valves or manual valves subject to regular operation, such as manifold valves, will be subject to special consideration and may be accepted without the removable caps.

3.12.3.3. Isolation arrangements are to be provided for the filters, strainers and refrigerant dryers to enable their cleaning/replacement.

3.12.3.4. Manually operated bypass valves are to be provided for automatic expansion valves. Alternatively, duplicate automatic expansion valves will be accepted.

3.13. Tests and Inspections

3.13.1. **Equipment to be constructed under survey**

All major items of equipment are to be surveyed at the manufacturer's works. The workmanship is to be to the Surveyor's satisfaction and the Surveyor is to be satisfied that the components are suitable for the intended purpose and duty. Examples of such units are:

- Crankshafts, crankcases, rotor shafts and casings for all compressors.
- Condensers.
- Evaporators (secondary refrigerant coolers).
- Air coolers.
- Pressure vessels (e.g. liquid receivers, surge drums, suction separators, intercoolers, oil separators).
- Cooling water pumps for condensers.
- Valves and other components intended for installation in pressure piping systems having a maximum working pressure greater than 7 bar.
- Thermal insulating panels (factory made).

3.13.2. **Type approved equipment**

Where it is proposed to use components (e.g. compressors, condensers, oil separators) which have valid IRS Type Approval or General Approval Certificates, the types and model numbers of the components are to be stated. Plans of components that have been so approved need not be re-submitted.

3.13.3. **Compressor**

3.13.3.1. The Surveyor may not witness the material tests but is required to verify the materials used.

3.13.3.2. In the presence of the attending Surveyors, the pressure boundary components of the compressor are to be hydrostatically tested to 1.5 times the design pressure.

3.13.3.3. In the presence of the attending Surveyor, in addition to the hydrostatic test specified in 3.13.3.2, the compressors are to be leak tested at the design pressure on the LP and HP side, as appropriate. This leak test may be done using the mediums referenced in 13.1.1.

3.13.3.4. After accomplishment of the tests referred to in 3.13.3.2, functional and capacity testing of the compressor is to be conducted at the manufacturer's plant in the presence of the Surveyor and as per an approved program. The functional tests should comprises of recording of the refrigerant used, pressures, temperatures, testing of alarms and shut down, pressure relief devices and vibration measurements to ascertain that the limits do not surpass those proposed by the manufacturer and that other features relating to the performance of the equipment are as per the specification. Similarly, during the capacity test, power consumption and the refrigeration loads are to be recorded.

Eventually, the attending Surveyor will issue a certificate documenting the functional and capacity tests that were performed.

3.13.4. **Pressure Vessels**

3.13.4.1. In the presence of the attending Surveyor, pressure vessels comprising of coolers, condensers and heaters under refrigerant pressure are to be hydrostatically tested by the manufacturer to a test pressure equal to 1.5 times the design pressure. The condenser, heaters and evaporators are to be pressure-tested on both shell sides and tube.

3.13.4.2. Pressure vessels in the refrigerant and the brine system are to be leak-tested and the procedure followed is to be as per Ch-13, 13.1.1.3.

3.13.5. **Piping**

3.13.5.1. In the presence of the attending Surveyor, after fabrication (e.g. attachment of flanges and fittings, bending, etc.), all refrigerant and brine pipes are to be subjected to a hydrostatic test pressure at 1.5 times the design pressure. Alternatively, the test may be performed pneumatically using an appropriate inert gas such as nitrogen.

3.13.5.2. As per the procedures in Ch-13, 13.1.1.3, the refrigerant and the brine piping are to be leak-tested at the design pressure.

3.13.5.3. Refer to Chapter 13 for tests after installation.

3.13.6. **Pumps**

3.13.6.1. At the manufacturer's plant in the presence of the Surveyor, refrigerant pumps and brine pumps are to be tested. The pumps are required to meet the hydrostatic and capacity test requisites of Part 6, Ch-8, 1.4.3.2.

3.13.6.2. As per 13.1.1.3, the refrigerant and the brine pumps are to be leak-tested at the design pressure.

3.13.7. **Relief Devices**

The setting of the relief devices are to be substantiated by the Surveyor.

CHAPTER 4 REFRIGERANT CARGO SPACES

CONTENTS

4.1. General

All air cooler rooms and refrigerated cargo spaces are to have access doors, hatches and ladders arranged for easy access and escape. Access doors to the refrigerated spaces are to open outwards, alternatively sliding doors may be used where the door is external to the space. Access ways to the refrigerated spaces are to be designed to facilitate escape in emergencies, and the removal of stretcher-borne personnel.

4.2. Design considerations

4.2.1. To accommodate pallets of a height specified by the Owners/builders, where cargo spaces are intended to carry palletized cargo, the minimum clear height in between deck cargo spaces is to be consistent throughout and is to embrace a minimum air gap above the pallets of 100 mm (4 in.) for air circulation.

4.2.2. The owner or builder may install cargo space heating or other means for maintaining cargo space transport temperatures for vessels that are proposed to operate in regions where ambient temperatures are expected to be lower than the cargo space temperatures. These systems should have appropriate controls for maintaining the desired temperature.

4.2.3. When using either fork lift trucks or pallet trucks, the grating, insulation, lining and spar deck planking is to be so sturdy so as to support the weight of a fully loaded truck carrying the heaviest load envisioned during normal loading and unloading. This is to be demonstrated as per tests specified in 4.13.3.

4.2.4. **Corrosion and Protection**

4.2.4.1. Hull Structure

a) All steel surfaces are to be cleaned of grease and other organic contaminants and are to be abrasive-blasted to near white finish (SSPC-SP-10, NACE No.2, SWEDISH SA 2.5) or to an alternative finish as per the paint manufacturers specification before coating. This may be done before erection and welding, in which case special attention is to be given to the preparation of the welded areas.

b) Steel surfaces of refrigerated cargo spaces, behind insulation and comprising of the inside of hatch coamings are to be coated to a minimum dry film thickness of 150 microns (6 mils). Similarly, steel work and fittings, which are to be covered with insulation, are to be cleaned and then coated to prevent corrosion. Where to the steel structure and bulkheads, polyurethane foam is applied directly, the surfaces are to be prepared to ascertain proper adhesion and resistance to corrosion.

c) Openings in the refrigerated cargo spaces such as the bilge limbers and plugs and other openings to these spaces such as the hatch covers and access doors are to be either constructed of moisture resistant material or covered with such material.

d) An oil impervious coating is to be applied on the surface of the tank plating where the tank top or bulkhead of an oil storage tank forms part of the refrigerated cargo space walls.

4.2.4.2. Fittings and Fixtures

Nuts, steel bolts, screws, washers, hangers and other similar fixtures which support or secure pipes, insulation, meat rails, etc., are to be protected against corrosion with the help of galvanizing or other equally effective methods approved by IRS.

4.2.4.3. Pipes, Ducts and Drip Trays

a) Refrigerant and brine pipes in the refrigerated cargo spaces are to have corrosion protection as per Ch-3, 3.12.2.

b) All steel ducts and pipes passing through the refrigerated cargo spaces are to be secured against corrosion before the application and installation of the insulation.

c) Steel drip trays provided under air coolers and vertical cooling grids are to be galvanized or epoxy coated. Materials other than steel such as flake glass or plastic may be used for the construction of the drip trays, provided the material used is apt for the proposed application and has been approved by IRS.

4.3. Insulation

4.3.1. The materials, insulation arrangement, construction and installation are to be as per the approved plans and to the satisfaction of the Surveyors.

4.3.2. Where the prefabricated insulating panels are used for insulation, those panels are to be approved by IRS. During the manufacture of these panels, inspections by the Surveyors are required.

4.3.3. The manufacturing of the panels referred to in 4.3.2 may be accepted under the quality assurance program, when requested.

4.3.4. **Types**

Polyurethane, Rockwool, Styrofoam, glass fiber or equivalent material may be used for insulation purposes.

4.3.5. **Properties**

4.3.5.1. The insulation material used in the refrigerated cargo spaces is to be of such type that does not produce or absorb paint.

4.3.5.2. Organic foam is to be fire retardant as acknowledged by a recognized fire test procedure such as DIN 4102.B2. Test certificates issued by independent testing laboratories in this regard are to be submitted for review.

4.3.5.3. The insulation material is to be tough and should not distort or deform due to the temperatures which will be encountered in service. During normal conditions, it should also be capable of bearing shipboard vibrations which are likely to occur.

4.3.5.4. Where applicable, having regard to their location and environmental conditions, insulation arrangements are to have:

a) materials suitably resistant to fire;

b) insulation lining suitably resistant to flame spread;
c) effective protection against penetration of water vapour; and
d) adequate protection against mechanical damage.

4.3.5.5. The potential for smoke generation and toxicity of insulation materials is to be in accordance with SOLAS Chapter II-2, Part B, Regulation 6.

4.3.6. **Temperature Gradient Calculation**

4.3.6.1. Over all surfaces, the thickness of insulation is to be as per approved specifications and plans.

4.3.6.2. Around the open edges, thermal bridges associated with fittings for securing the panels and moisture barriers are to be accounted for in the calculations.

4.3.6.3. Where adjoining the refrigerated cargo spaces, machinery spaces and other such spaces fitted with heating arrangements such as fuel tanks, etc., are situated, the heat transfer calculations are to be taken into account.

4.3.7. **Installation**

4.3.7.1. It is required to efficiently pack and securely fasten the insulation.

4.3.7.2. The slabs or blocks, where used for insulation, are to have the joints staggered and butted as close as possible. Even for several layers of insulation blocks, this applies and wherever they are employed, these are also to be installed in a similar manner. Any inevitable gaps between the joints and crevices are to be filled with an appropriate insulating material.

4.3.7.3. Panels are to be so sturdy that with their inherent mechanical strength they can bear, without damage, loads due to over or under-pressure of the refrigerated cargo spaces resulting from rapid cooling of the refrigerated cargo space or the defrosting of coolers. Suitable pressure equalizing devices are to be fitted as an alternative arrangement.

4.3.7.4. During the installation of the prefabricated insulation panels, it is to be ascertained that the panels are butted together in a manner that all joints along the edges and the corners are sealed at both the outer and inner sides to form a vapor barrier using an approved sealant. A similar method is to be employed at floors, ceiling intersections and the vertical bulkheads.

4.3.7.5. At the open edges of the panels such as at the footing, corner intersections, openings for doorways, etc., provisions are to be made in the design for an effective moisture barrier.

4.3.7.6. Partitions, decks and other structural members which extend into refrigerated cargo spaces from the ship side, machinery spaces or other such non-refrigerated adjacent spaces are to be effectively insulated over a length of at least 1 m (3.3 ft) into the refrigerated cargo space unless temperature gradient calculations prove less carry-over is adequate.

4.3.8. **Lining**

4.3.8.1. Using a suitable lining material such as marine plywood (coated), metallic sheet or other similar material, the insulation is to be protected from water and water vapor as those materials are impervious to water.

4.3.8.2. The insulation lining referred to in 4.3.9.1 is to be installed in such a way as not to allow water to penetrate into the insulation during hosing down of the chambers.

4.3.8.3. Lining, cooler room screens and structures supporting these are to be of adequate strength to bear the loads imposed by either the refrigerated or general cargo in transit.

4.3.8.4. Where plywood is used, it is to be treated against dampness, fungi and other microorganisms.

4.3.8.5. The timber used in insulation embedding is to be impregnated under pressure with odorless preservative. All sawn ends and bolt holes to be treated in situ.

4.3.8.6. A metallic plate of minimum height 500 mm (1.6 ft) and thickness of 6 mm (0.24 in.) is to be provided at deck level to secure the lining against damage from forklift trucks or pallet jacks. Alternative heights and thicknesses proposed by the Owner/builder will be specially considered. Other materials such as glass reinforced plastics may be used, if it is demonstrated to the satisfaction of IRS to be of appropriate strength and durability.

4.3.9. **Insulation of Pipes, Ducts and Vent Trunks**

4.3.9.1. To avoid freezing, vent, sounding, overflow and water pipes are to be insulated from cold surfaces such as the bulkheads and decks and installed so that contact with the warmer surfaces such as the vessel side is maintained as much as possible. Where this is not feasible, heat tracing of these pipes is to be fitted.

4.3.9.2. Ducts and pipes passing through refrigerated cargo spaces are to be well insulated.

4.3.9.3. Where space being monitored has partially inserted thermometer tubes, the portion of the tube external to that space is to be well insulated.

4.3.10. **Penetration of Insulation**

4.3.10.1. As per the approved plans, plugs provided for access to manhole covers, bilge suction wells, drains, etc. are to be insulated.

4.3.10.2. Openings for manholes and bilge covers are to be fitted with liquid tight steel coamings to prevent seepage of water into the tank top insulation. The height of the coaming is not to be less than the insulation. To prevent seepage into the insulation, a sealant may be applied at the edges.

4.3.10.3. Pipes, ducts and cable penetrations are to be made airtight.

4.3.10.4. Provisions for inspection during the periodical surveys of the bilge suction pipes, vent and sounding pipes and other similar pipes situated behind the insulation are to be made in the installation of the insulation. This may be attained by installing removable insulation panels or other methods approved by IRS.

4.4. Stowage and Side Shoring

4.4.1. Provisions to ensure the circulation of air between the cargo and the insulation lining surfaces are to be made.

4.4.2. Cooling grids situated on vertical surfaces are to be secured by dunnage ribs.

4.4.3. Side shoring is to be of adequate strength to bear the dynamic loads imposed by palletized cargo in shipment.

4.5. Air Circulation and ventilation

4.5.1. Upon the air volume of empty refrigerated cargo spaces, the required air circulation and fresh air ventilation rates are to be based.

4.5.2. The design of the air circulation system in refrigerated cargo spaces proposed for the transportation of fruit is to ascertain an adequate flow of chilled air all through the stow in the loaded condition.

4.5.3. For refrigerated cargo spaces fitted with coolers with forced air circulation, upon the nature of the cargo and the design temperature, the quantity of circulating air for each refrigerated cargo space is to be based but shall not be under 30 air changes per hour. For frozen cargoes, lower air circulation rates will be considered.

4.5.4. In case of fruit carriers, the cooling fans are required to have the ability of running at least two speeds so that the air circulation rates in the refrigerated holds can be maintained at not less than 45 and 90 air changes per hour.

4.5.5. Refrigerated cargo spaces proposed for transmitting fruit must also be provided with a fresh air mechanical ventilation system rendering at least 2 air changes per hour.

4.5.6. Air circulation and fresh air ventilation rates lower than those stated in 4.5.3, 4.5.4 and 4.5.5 will be considered subject to the submission of an assessment of the heat to be removed, nature of cargo, etc.

4.5.7. Each refrigerated cargo space proposed for the transportation of fruit is to be rendered with its own distinct inlet and exhaust vent. The position of the air inlet is to be chosen to minimize the possibility of contaminated air entering into any refrigerated cargo space.

4.5.8. For details of the ventilation when the vessel is occupied with transportation of cargoes other than refrigerated cargoes, reference is to be made to the requisites contained elsewhere in the Rules.

4.6. Ducts, Gratings and Spar Decks

4.6.1. It is required that cooling air from the fan unit is evenly distributed at the bottom of the refrigerated cargo spaces.

4.6.2. The size and number of ventilation holes and height of the gratings are to be appropriate for the air circulation requisites.

4.6.3. The size and number of ventilation holes in the spar deck planking are to be suitable for the air circulation requisites.

4.6.4. Appropriate arrangements are to be made to allow ease of lifting of the gratings for easy cleaning and maintenance of the deck beneath.

4.6.5. In every refrigerated cargo space, the grating and related supports lying directly underneath the hatch opening and 600 mm (2.0 ft) beyond, are to be designed so as to bear impact during loading. Increased grating thickness and/or reduced spacing of the supports will be considered, in case the air circulation is not adversely affected. The security of insulation in grating less cargo spaces is to be no less effective.

4.7. Bilge and Drainage Arrangements

4.7.1. The bilge system for cargo spaces is to be in terms with Part 6, Ch-9, Sec-3, 3.3.

4.7.2. Cooling grids fitted vertically on the refrigerated cargo space sides and air coolers are to be endowed with drip trays and drain pipes arranged as given below:

4.7.2.1. Drain pipes are to be sized such that drainage without overflowing of the drip trays during defrosting operations is permissible, taking into account the vessel's motion.

4.7.2.2. For cleaning, drainage openings in the drip trays are to be quickly accessible.

4.7.2.3. Flanged connections near the outlets allow cleaning of the drain pipes in the event of blockage.

4.7.2.4. When transmitting frozen cargo, trace heating of the drain pipes and drip trays is to be provided.

4.7.3. All refrigerated cargo spaces are to have sufficient continuous drainage with water lock facilities [inbuilt liquid seal traps].

4.7.4. To prevent air and water from leaking into adjoining refrigerated cargo spaces, provisions are to be made.

4.7.5. To prevent air from leaking into adjoining refrigerated cargo spaces, open ended pipes such as drains from each deck space or the drip trays from these spaces are to have in-built liquid seal traps or non-return valves. These requisites are also applicable to drains underneath the coolers.

4.7.6. When drains from different segregated refrigerated cargo spaces join in a common main, the branch lines are to be rendered with liquid seal traps to prevent air from leaking into adjoining refrigerated cargo spaces. In addition, branch lines from lower spaces are to be endowed with non-return valves to prevent flow of water from one compartment to the other.

4.7.7. In areas subject to freezing, liquid seal traps shall be so sited that they are filled with brine and are easily accessible for maintenance purposes.

4.7.8. Drains from other spaces are not to lead to the bilges of refrigerated cargo spaces.

4.7.9. Bilge wells where drain pipes are led, and connections to the main bilge system are to be segregated from refrigerated cargo spaces by air tight moisture resistant divisions.

4.8. Pipes passing through Refrigerated Cargo Spaces

4.8.1. Sounding pipes are to be not less than 32 [mm] bore.

4.8.2. All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces or the insulation thereof, in which the temperatures contemplated are 0°C or below, are to be not less than 65 [mm] bore.

4.8.3. Sounding pipes to oil compartments are not to end within refrigerated chambers or in the fan and battery rooms for these chambers, nor are these pipes to cease in enclosed spaces from which access is provided to refrigerated cargo chambers or their battery and fan rooms.

4.8.4. All pipes, including air pipes, scupper pipes and sounding pipes that pass through chambers, proposed for the transportation or storage of refrigerated produce are to be well insulated.

4.8.5. As much as possible, air, sounding and tank filling pipes which go via insulated spaces are to be arranged in close proximity to the shell and bulkhead structure. Flanged joints are to be kept to a minimum, and where additional supports are essential, brackets are to be fitted.

4.8.6. Where the pipes, referred to in 4.8.4 go through chambers proposed for a temperature of 0°C or below, they are also to be insulated from the steel structure, except in sites where the temperature of the structure is majorly controlled by the external temperature and will normally be above freezing point. Pipes going through a deck plate within the shipside insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deck-plating. In the case of pipes adjoining shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as much as possible.

4.8.7. The insulation from steel work is, however, not required for air refreshing pipes to and from refrigerated compartments.

4.8.8. Steel pipes penetrating the tank top in refrigerated cargo spaces are to have a wall thickness of a heavier grade in way of the insulation and the tank top.

4.8.9. Sounding pipes for oil tanks are not to cease in refrigerated cargo spaces or air cooler rooms.

4.9. Air-tightness of chambers

4.9.1. The following Rules are majorly concerned with evading infiltration of gases, odours, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause unwanted frosting of cooling equipment.

4.9.2. Each individual chamber is to have steel construction throughout and hose-tested for tightness. Alternative proposals will be considered to test more thoroughly by gas or air under slight pressure.

4.9.3. It will be given consideration that the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers, where the chambers concerned are proposed for cargo which will not taint or otherwise adversely affect the cargo in any other chamber; for instance, gases given out by fruit of one category may unfavorably affect fruit of another category by encouraging rapid ripening or, alternatively, unfavorable organic effect.

4.9.4. Access doors, hatch closing appliances, tonnage doors, bilge and manhole plugs forming part of the insulated envelope of independent refrigerated chambers, are to be made air tight. Where hatch covers or plugs are exposed to ambient conditions, they are to be rendered with a double seal.

4.9.5. Ducts, ventilators or pipes going through refrigerated chambers to other compartments are to be made airtight and appropriately insulated. Specific attention is to be given to insulation linings forming surfaces of air ducts. If ventilators to refrigerated spaces are fitted, they are to be provided with airtight closing appliances.

4.9.6. Refrigeration pipes going through bulkheads or decks of refrigerated cargo chambers are not to be in direct contact with the steel work, and the holes through which they pass are to

be true and of an apt finish for effectively sealing by the method proposed. It is suggested that holes be trepanned and not burnt out. The air tightness of the bulkheads and decks is to be maintained.

4.9.7. Where cooling pipes go through watertight plating and bulkheads, the fittings and packing of the glands are to be both watertight and fire resistant. Outside the chambers that refrigerating pipelines serves, they are to be effectively, except within insulated brine cooler and control rooms.

4.9.8. Bilge limbers and plugs, Insulation lining and chamber and access doors are to be made of water-vapour resisting material, or covered with them, and where exposed to bilges or external conditions, they are to be sealed.

4.10. Access plugs and panels

4.10.1. Insulated plugs are to be provided in the insulation where required for easy access to the bilge suction roses, bilges, cooler and chamber drains and tank manhole lids. Detachable panels are to be there for access to tank air and drains and sounding pipes.

4.10.2. It is suggested that a number of small insulated inspection plugs be fitted for leak detection where the insulation is covered with reinforced asphalt.

4.10.3. When insulation is to be fitted in way of tank plating, the surface of oil storage tank tops and bulkheads are to be applied with many coatings of an approved oil impervious composition. Depending on the construction of the tank, the composition used and the method of application, the total thickness of the coating required is decided upon.

4.10.4. To prevent seepage into insulation, a liquid tight steel coaming is to be placed in the tank top insulation in way of manholes and bilge hats.

4.11. Air-tightness of insulation lining and air ducts

4.11.1. The construction of air ducts and insulation linings are to be such that moving air is prevented from entering the insulation. Where air refreshing ducts, cooling pipes, fan supports, etc., protrudes through the lining, special care is required.

4.12. Cargo battens

4.12.1. Where it is intended to transport the fruit and provision is made for adequate air circulation through stow, then cargo battens may be omitted.

4.12.2. Where it is intended to transport frozen cargo, provision is to be made for the circulation of air between the insulation lining and the frozen cargo. Where cargo battens are used to maintain the air passage, they may be integral with the lining, fastened to the lining, or added as dunnage during cargo loading, to all exposed vertical or near vertical, surfaces of the insulation lining. They are to be arranged to go well with the air flow.

For the purpose of providing an air passage, they need not be fitted to air screens and cooler casings. Where carrying refrigerated cargo within the hatch trunk is proposed, a full flow of air over the cargo and below the hatch covers is considered vital. The air flow may be promoted with the help of air trunking or special battening arrangements.

4.13. Tests and Inspections

4.13.1. The results of the corrosion resistance coating thickness measurement are to be submitted by the shipyard to the attending Surveyor.

4.13.2. The Surveyor is to validate the adequacy of the seals and traps for each refrigerated cargo space.

4.13.3. The test required by 4.2.3 on the insulation and lining is to be executed in the presence of the attending Surveyor as given below:

A 4x4 m (13x13 ft) sample of the cargo floor construction, including insulation, is to be prepared and tested by a fully loaded fork lift truck with its mightiest load envisioned during normal loading and unloading operations being driven and maneuvered over the sample. Where cargo operations will not involve forklift trucks, a similar test using a fully loaded pallet truck is to be executed.

4.13.4. Insulation thickness on valves, pipes, flanges and fittings is to be inspected by the attending Surveyor.

4.13.5. Sample tests executed by the manufacturer to determine the density of the insulating material are to be submitted to the Surveyor for substantiation that the material conforms to the design specification.

4.13.6. Where insulating foam is proposed to be applied directly to the ship's structure, the method of application and the procedure are to be approved before the commencement of work.

4.13.7. For prefabricated panels referred to in 4.3.2, the insulation material is to be as per 4.13.5.

4.13.8. Refer to Ch-13, 3.2.1.3 for air distribution tests.

CHAPTER 5 ANCILLARY SYSTEMS

CONTENTS

5.1. Cooling Water Systems

5.1.1. Design Considerations

5.1.1.1. Valves, cooling water pipes and fittings are to be in terms with the requirements of Part 6, Ch 8 & Ch 9.

5.1.1.2. The supply of cooling water for condensers is to be obtainable from minimum two independent sea connections, one preferably on the port and the other on the starboard side.

5.1.1.3. The maximum cooling water velocity through each condenser is not to exceed manufacturer's recommendations.

5.1.2. Pumps

Minimum two independent pumps are to be installed for the supply of cooling water to the refrigeration unit(s), one of which is to act as a standby. The standby pump may be used for other general service duties, except oil and bilge systems, provided its capacity is adequate to simultaneously maintain the required supply of cooling water to the refrigeration unit(s).

5.1.3. Shell Connections

5.1.3.1. Shell connections are to be as per the requirements of Part 6, Ch 8, Sec-2.

5.1.3.2. The overboard valve is to be of a spring loaded type if the elevation of the condenser relative to the light water line is such that the manufacturer's suggested back pressure cannot be maintained in the overboard discharge line.

5.1. Bilge and Drainage Systems

The refrigerating machinery space is to be properly drained. Bilge arrangements are to be as per Part 6, Ch 9, Sec-3.

CHAPTER 6 FIRE EXTINGUSIHNG SYSTEMS AND EQUIPMENT

CONTENTS

6.1. Cargo Spaces

In conformation to the requirements of Part 6, Ch-3, Sec-4, 4.7, refrigerated cargo spaces are to be provided with a fixed fire extinguishing system. Where gas smothering system is used, the arrangements are to be as per Part 6, Ch-3, Sec-4, 4.7.1.

6.2. Refrigeration Machinery Spaces

Where refrigeration machinery is located in a dedicated space, minimum two portable fire extinguishers conforming to Part 6, Ch-3, Sec-4 are to be provided in the space. One of the required portable fire extinguishers is to be stowed near the entrance to the space.

6.3. Refrigerant Storage Space

Spaces other than those referred to in 6.2 above, which has refrigerant cylinders, are to be rendered with minimum one portable fire extinguisher conforming to Part 6, Ch-3, Sec-4, which is to be stowed near the entrance to the space.

CHAPTER 7 ELECTRICAL SYSTEMS

CONTENTS

7.1. General

Except as noted herein, conformation to Part 7, as applicable, is needed.

7.2. Cable Installation

Cables are not to be embedded in the insulation or installed behind. They may, however, go through such insulation at right angles; subject to they are safeguarded by a continuous pipe with a stuffing tube at one end. For bulkhead penetrations, these stuffing tubes are to be on the un-insulated side of the bulkhead and for deck penetrations at the upper end of the pipe.

7.3. Electrical Installation in Refrigerating Machinery Room and Cargo Hold

7.3.1. The electrical accessories installed in the refrigerating machinery room, such as detectors, switches, junction boxes, etc. are to have IP44 enclosure and rest of the electrical equipment is to have IP22 enclosure.

7.3.2. It is required to secure electrical equipment installed in the cargo holds from mechanical damage. IP55 enclosure is mandatory for all electrical equipment in the cargo holds.

7.3.3. Electrical equipment installed in the ammonia refrigerating machinery spaces is to be as per Ch-9, 9.7.2.

7.4. Power Supply

The electrical power is to be available from at least two generating sets where the refrigerating plant is electrically driven. The capacity of the generating sets is also to be such that, in addition to ascertain the operation of the services necessary for the propulsion and safety of the ship and services for providing minimum comfortable conditions of habitability, as required by Part 7, Ch-2, Sec-2, 2.1, the following conditions are met:

7.4.1. Aggregate capacity of the generators is to be adequate to supply the power to the refrigerating plant(s) mentioned in 3.2.2.2(a) or 3.2.2.3(a). Where the vessel is designed for the simultaneous transportation of integral refrigerated containers on deck, the aggregate capacity of the generators is to be adequate to supply power to the refrigerated cargo spaces mentioned above and all of the electrical power sockets for these containers, to enable all modes of operations including cool down.

7.4.2. Where it is not vital to supply power simultaneously to all the electrical sockets due to operational requirements, where fitted, for the refrigerated containers on deck, alternative aggregate capacity of power supply from the generators to that required in 7.4.1 will be considered.

7.4.3. When one of the generator is out of action, the rest of the generator(s) are to be capable of supplying adequate power to the refrigerating plant(s) and/or electrical power sockets so as to attain and maintain the required steady state temperature in all of the loaded cargo spaces and/or containers when operating under the conditions specified in 3.2.2.1, subject to the applicability of 7.4.2.

7.5. Transformer

7.5.1. Where the refrigerating plants are supplied by power through converters or transformers , the system is to be so set that the continuity of the power supply to the refrigerating plants is ensured, as follows:
With any one transformer or converter out of action, a standby transformer or converter is to be capable of supplying the power to the refrigerating plants. Alternatively, this

requirement may be met, provided there are alternative arrangements for supplying power to the circuit upon failure of the converter or transformers.

7.6. System Design

Coordinated tripping is to be there between feeder and branch circuit protective devices for refrigerating plants.

7.7. Testing and Inspection

7.7.1. Motor Control Centers and Distribution Boards

Testing of motor control centers used for refrigerant plants are to be performed as per Part 7, Ch-4, Sec-4, 4.1.2.9, in the presence of the Surveyor.

For distribution boards, the manufacturer is to perform the testing as per Part 7, Ch-4, Sec-4, 4.1.2.9 and the provided Certificate of Tests will be acceptable.

7.7.2. Motors

Motors of 100 kW (135 hp) and over are to be tested in the presence of the Surveyor in accordance with Part 7, Ch-4, Table 4.4.1. For motors below 100 kW (135 hp), the tests as per Part 7, Ch-4, Table 4.4.1 may be done by the manufacturer whose certificates of tests will be acceptable.

7.7.3. Electrical Installation

Testing of the electrical installation for refrigeration machinery is to be executed as per Part 7, Ch-8, Sec-7, 7.6.

CHAPTER 8 INSTRUMENTATION, CONTROL AND MONITORING

CONTENTS

8.1. General

8.1.1. It is required to ascertain and maintain selected carriage temperature for the individual cargo spaces during all service conditions with the help of the control and monitoring systems. The monitoring system is to be there for refrigerating machinery and refrigerated cargo space temperatures.

8.1.2. For fruit carriers, additionally, the monitoring and control systems are there to ascertain that the CO_2 levels in cargo spaces are constantly monitored and the levels selected are not surpassed during all service conditions.

8.2. Control

8.2.1. Instrumentation, control and monitoring required for operation may be provided at or in the vicinity of the refrigeration machinery, the navigation bridge, the centralized control and monitoring station of the propulsion machinery or other similar spaces.

8.2.2. Where the refrigeration machinery is remotely controlled from the navigation bridge, the centralized control and monitoring station of the propulsion machinery or other similar spaces, means of independent controls and instrumentation and monitoring required for operation are to be provided at or in the vicinity of the refrigeration machinery, together with means provided locally to disconnect or override allied remote controls.

8.2.3. Refer to Table 8.2 for requisite displays and alarms.

8.2.4. The control and monitoring for the temperature of circulating air entering and exiting each air cooler is to be independent from each other.

8.3. Temperature Measuring Equipment

8.3.1. **Minimum Number of Sensors**

For guidance, in a refrigerated space, the minimum required number of sensors is to be determined based on the geometry and capacity of the space, as given below:

4 for up to 250 m^3 (8.828 ft^3) space
5 for up to 400 m^3 (14.124 ft^3) space
6 for up to 700 m^3 (24.178 ft^3) space
7 for up to 1200 m^3 (42.373 ft^3) space
8 for up to 1900 m^3 (67.090 ft^3) space
10 for up to 2800 m^3 (98.870 ft^3) space

8.3.2. **Location of Sensors**

In each refrigerated space with forced air circulation through air coolers, in addition to 8.3.1, minimum one sensor is required for the circulating air. Also see 8.2.4.

8.3.3. **Remote Temperature Measurement**

8.3.3.1. Sensors in refrigerated spaces are to be so set that temperature reading is possible without entering the spaces.

8.3.3.2. Each refrigerated cargo space is to be rendered with at least two temperature measuring instruments with its own power supply so that in the event of a fault in any one of the measuring instruments, the temperature measurement of the space is possible.

8.3.3.3. For maintaining a log of cargo hold temperature, temperature reading devices or similar means are to be fitted.

8.3.3.4. Where an individual source of power supply, such as transformer, converter or battery supplies temperature measuring systems, a stand-by source of power is to be provided. This requirement may also be satisfied, provided there are alternative arrangements for supplying power to the circuit upon failure of the transformer, converter or battery.

8.3.3.5. Arrangement and number of the remote temperature measuring system sensing elements is to be in terms with 8.3.1 and 8.3.2. The temperature sensing elements are to be permanently connected to their instruments and well-secured against damage.

8.3.4. **Accuracy, FSD (Full Scale Deflection) Range**

8.3.4.1. The measuring range of the system is to cover the whole of the anticipated temperature range plus an additional ±5°C (9°F).

8.3.4.2. The accuracy of the temperature measuring equipment is to be within ±0.5°C (0.9°F) for frozen cargo and ±0.2°C (0.4°F) for fruit.

8.3.4.3. Depending on the cargoes transmitted, accuracy of instrumentation to a value higher than that stated in 8.3.4.2 above is required by some Administrations. Accordingly, due attention is to be given to the requirements of various Port States during the design stages of the temperature monitoring and control systems, if it is required for the vessels to transport cargoes to and from these ports.

8.4. CO_2 Measuring Equipment

All refrigerated cargo spaces proposed for transmittance of fruit are to be fitted with permanently installed equipment for indication of CO_2 content. The sensors are to be appropriately positioned in the cargo spaces and are to be located away from the fresh air ducts.

8.5. Refrigerant Leakage Detection

8.5.1. Where the quantity of the refrigerant charge in the largest system exceeds the following per unit volume of the spaces in which it is located, the spaces having the refrigerating machinery, and in the case of a direct expansion system, the refrigerated cargo spaces, are to be rendered with a refrigerant leakage detection system in terms with 8.5.2 and 8.5.3.

Table 8.1

Refrigerant	Concentration, kg/m^3 (lb/ft^3)
R 22	0.14 (0.009)
R 134a	0.25 (0.016)
R 404a	0.48 (0.030)
R 407a	0.33 (0.021)
R 407b	0.35 (0.022)
R 407c	0.35 (0.022)
R 410a	0.44 (0.028)
R 410b	0.43 (0.027)
R 507	0.49 (0.031)

8.5.2. The Refrigerant vapor detection system is to give an alarm and initiate mechanical ventilation in the event of refrigerant concentration surpassing the time-weighted average to which personnel may be repeatedly exposed to in the spaces. See Table 8.1

8.5.3. The refrigerant vapor detection system referenced in 8.5.2 is also to be set in a manner to give an alarm and initiate mechanical ventilation when the refrigerant concentration surpasses a level where oxygen levels in the refrigerant machinery space are below 19.5% by volume. Alternatively, sensors for monitoring the oxygen level in the machinery space may be fitted and arranged to give an alarm when and if oxygen level drop down to19.5%.

8.6. Instrumentation and Monitoring

The indications and alarms as per Table 8.2 are to be provided at or in the vicinity to the refrigeration machinery, the centralized control and monitoring station of the propulsion machinery, the navigation bridge or other similar spaces.

Table 8.2 Instrumentation and Alarms

Item			Display	Alarm	Remarks
Compressor	Automatic stop			Activated	
	Lubricating oil		* Pressure	Low	Automatic stop (Low pressure)
	Driving motors		Running	Stop	
	Available driving motors		Running	Start	For auto start
	Discharge line	- Pressure	* Pressure	High	Automatic stop (High pressure)
		- Temperature	*Temperature	High/Low	Automatic stop (High pressure)
		- Superheat	*Temperature	High	Automatic stop
	Suction line	- Pressure	*Pressure	Low	Automatic stop (Low pressure)
		- Temperature	*Temperature	High	
		- Superheat	*Temperature	Low	Automatic stop (Low pressure)
	Intermediate stage (if fitted)		*Pressure	High	Automatic stop (High pressure)
Brine Lines	Brine pumps		Running	Stop	
	Available pumps		Running	Start	For auto start
	Brine cooler - inlet/outlet		*Temperature	High (outlet)	
	Pressure line		*Pressure	Low	
	Header tank		*Level	Low	
Condenser	Cooling water pumps		Running	Stop	
	Available cooling water pump		Running	Start	
	Cooling water - inlet		*Temperature		
	Cooling water - outlet		*Temperature	High	
Refrigerant receiver	Level		*Level	High/Low	
Refrigerating Machinery space	O_2 content (or, excessive refrigerant vapor content)			below 19.5% (excessive)	
Refrigerant leakage	Concentration in Refrigerating machinery space			Leakage (ppm above as per 6-2-10/9.3)	
	Concentration in Refrigerated spaces			Leakage(10ppm)	Direct system
	Detection system			Failure	

Item		Display	Alarm	Remarks
Refrigerated spaces	Temperature measuring	Temperature	Deviation from set point	
	Left/Right hand cooler delivery air/return air	Temperature	Deviation from set point	
	CO_2 content	Percentage	Higher than the set point	For fruit carriers
	Fresh air fan (Full/Half speed)	Stop/Running/ Auto	Failure	
	Ventilation fan (Full/Half speed)	Stop/Running		For fruit Carriers
Relative Humidity	Percentage		Deviation from set point	
Defrost	Time duration		Disabled	
NOTE: Those devices marked (*) are to be provided at or in the proximity to the Refrigerating Plant given in Chapter-3.				

8.7. Alarm Call Button

At least one alarm call button is to be fitted near the exit point of all refrigerated spaces and air cooler rooms.

8.8. Automatic Controls

8.8.1. General

Where automatic control is fitted, observance of the following is required. Additionally, the arrangements are to be in line with 8.1 through 8.7.

The control systems are to be designed to automatically maintain the selected carriage temperature in the individual cargo spaces and, additionally, for fruit carriers, the CO_2 level.

8.8.2. Control and Monitoring

8.8.2.1. The alarms and the indication as listed in Table 8.2 are to be given at the locations mentioned in 8.2.1.

8.8.2.2. Instrumentation and means of independent control and monitoring vital for operation are to be provided at or in the vicinity of the refrigeration machinery.

8.8.2.3. Adequate arrangements are to be provided to disable the automatic control mode and restore manual control.

8.8.3. Alarm Systems

8.8.3.1. Alarm systems are to be of the self-monitoring type and designed so that a fault in the alarm system will cause it to fail to the alarmed condition.

8.8.3.2. Alarming of other faults that may happen during the acknowledgment process is not to be superseded by such an action.

8.8.3.3. Alarm systems are to be rendered with effective means of testing.

8.8.4. **Computer Based System**

8.8.4.1. Where alarms are displayed on a visual display unit, they are to appear in the sequence in which the incoming signals are received and are to have priority, regardless of the mode the visual display unit is in.

8.8.4.2. The computer program and related data considered to be necessary for the operation of the system is to be stored in non-volatile memory.

8.8.4.3. Software is to be validated as per a national, international or other recognized standard and demonstrated for substantiation.

8.8.5. **Testing of Equipment**

Testing of equipment related with automatic or remote control systems, monitoring systems and computer-based systems is to be as per Part 7, Ch-8, Sec-7. For equipment that has been validated by IRS on an individual basis or certified under the IRS Type Approval Program, the tests previously executed for conformation to Part 7, Ch-8, Sec-7 will be accepted, provided that the equipment being proposed is similar to the one previously tested.

8.9. Testing after Installation on Board

The following tests are to be executed to the satisfaction of the Surveyor:

8.9.1. It is required to demonstrate local control of the refrigerating machinery. This is to comprise of a demonstration of independent manual control and the disconnection or override of the automatic control system.

8.9.2. Where automatic control or remote control is there, the ability to control from a remote control station is to be demonstrated. This is to comprise of a demonstration to disable the automatic control mode and restore manual controls.

8.9.3. The required alarm control systems and displays are to be validated for satisfactory operation at the predefined set points.

8.9.4. The following equipment or systems are to be tested:

- The accuracy of the temperature measuring equipment as per 8.3.4.
- Alarm call button as per 8.7.
- CO_2 measuring system for refrigerated cargo spaces as per 8.4.
- Refrigerant leakage detection system as per 8.5.

CHAPTER 9 AMMONIA REFRIGERATION SYSTEM

CONTENTS

9.1. General

9.1.1. Refrigerating machinery that uses ammonia is to be designed, constructed and installed as per the requirements of this Section and other applicable requirements of the Rules.

9.1.2. In indirect refrigeration systems, ammonia may be used only as a primary refrigerant.

9.1.3. On-board refrigerated fish carriers, ammonia refrigerant for use in direct expansion systems will be specially considered subject to an assessment of all the features essential to ascertain the safety of the installation.

9.2. Design Considerations

9.2.1. Location of Refrigeration Machinery

9.2.1.1. Refrigerating units and associated equipment which have ammonia are to be sited in a dedicated space.

9.2.1.2. The dedicated space referred to in 9.2.1.1 is to be segregated by gastight steel bulkheads and decks from other spaces.

9.2.1.3. The compartment containing ammonia refrigerating machinery and any access ways are to be provided within dependent mechanical ventilation capable of:

- removing the heat generated by the equipment installed in the compartment;
- maintaining the atmosphere in the compartment at acceptable vapour threshold levels under normal operating conditions; and
- disposing of ammonia vapour safely and quickly in the event of a major leakage.

9.2.2. Access and Openings

9.2.2.1. Access doors to the refrigerated machinery space are to be as per the requirements given below:

a) A minimum of two access doors, located as distant as possible, are to be provided, one of which is to lead directly to the open deck. Water screens are to be there above access doors, operable manually from outside the compartment.

b) The access doors are to be gastight and self-closing with no holdback arrangements and are to open outward from the refrigeration machinery space.

c) Access doors are not to open to the accommodation spaces.

d) Where one access is from a Category ‘‘A’’ machinery space, it is to be fitted with double door separation having a minimum space of 1.5 m (4.9 ft) between each door. The doors are to be self-closing and gastight with no holdback arrangements and the space between each door is to be rendered with an independent ventilation system, the exhaust from which is to be led to atmosphere. If similar level of safety is maintained, alternative access arrangements will be specially considered.

9.2.2.2. Using the independent mechanical exhaust system, access corridors leading to the refrigerating machinery space are to be ventilated. This will not be required if the ventilation system required by 9.2.3 is also arranged to draw from the access corridors.

9.2.2.3. Duct, pipe and cable penetrations of bulkheads and decks of the ammonia refrigerating machinery spaces are to be made gastight.

9.2.3. **Ventilation of the Refrigeration Machinery Space**

The ammonia refrigerating machinery space is to be competently ventilated with help of mechanical exhaust ventilation designed as per the requisites given below:

9.2.3.1. The ventilation system is to be independent of other shipboard ventilation systems.

9.2.3.2. The ventilation system is to be designed for uninterrupted and constant operation.

9.2.3.3. A negative ventilation system, independent of ventilation systems serving other spaces. The capacity of the ventilation system is to be of adequate capacity to ascertain at least 30 air changes per hour based on the total empty volume of the space.

9.2.3.4. Ways for stopping the ventilation fans and closing the ventilation openings from a readily accessible position are to be provided.

9.2.3.5. Air inlet openings are to be positioned as low as practicable in the spaces being ventilated and exhaust openings as high as practicable to ascertain that no ammonia accumulates in the space.

9.2.3.6. Exhaust duct outlets are to be positioned at least 10 m (33 ft.) from air intake openings, openings to accommodation spaces and other enclosed areas, and at least 2 m (6.5 ft.) above the open deck.

9.2.3.7. Ventilation fans are to be of non-sparking construction as per Part 7, Ch-3, Sec-7, 6.17.

9.2.4. **Emergency Ventilation of Ammonia Refrigeration Machinery Space**

Ammonia refrigerating machinery spaces are to be rendered with a mechanical exhaust type gas evacuation system to rapidly dissipate a catastrophic leak of ammonia to minimize the risk of fire and explosion. The system is to be designed and constructed as per the requisites given below:

9.2.4.1. The gas evacuation system is to be independent of other shipboard ventilation systems; however, it need not be independent of the ventilation system required in 9.2.3.

9.2.4.2. The gas evacuation system is to be arranged to automatically initiate when the concentration of ammonia in the space surpasses 300 ppm.

9.2.4.3. The combined capacity of the ventilation and gas evacuation fans is to be based upon the larger of the following:

a) A volume to ensure 40 air changes per hour based on the total empty volume of the space;
OR;
b) The capacity calculated using the following formula:

$$Q = k \overline{G}$$

Where

k = 0.07 (3.66)
Q = minimum combined capacity, in m^3/s (ft^3/s)
G = mass of ammonia in the largest refrigerating unit, in kg (lbs)

9.2.4.4. The gas evacuation system controls are to be sited outside of the space.

9.2.4.5. The exhaust duct outlets are to be positioned at least 10 m (33 ft.) from air intake openings, openings to accommodation spaces and other enclosed areas, and at least 2 m (6.5 ft.) above the open deck. In addition, the vent outlets are to be directed upward and arranged such as to ascertain the discharge of any ammonia vapors would be away from accommodations and other occupied areas.

9.2.4.6. Gas evacuation fans are to be of non-sparking construction as per Part 7, Ch-3, Sec-7, 6.17.

9.2.5. **Drainage of Ammonia Refrigeration Machinery Space**

9.2.5.1. The ammonia refrigerating machinery space(s) is to be fitted with an independent bilge system.

9.2.5.2. The deck plating is to be arranged to facilitate easy cleaning and drying. No other plating above the deck is to be there.

9.2.5.3. Where a deluge system (see 9.2.6) is fitted, the drainage and pumping arrangements are to be such as to avoid the build-up of free surfaces. The drainage system is to be sized to remove not less than 125% of the capacity of the water-spraying system.

9.2.6. **Deluge System**

Where a water deluge system is fitted, the emergency gas evacuation system in 9.2.4 may be reduced by 20%. The water deluge system arrangements are to be as given below:

9.2.6.1. The system is to be independent but may also be used for supply to the water screens required by 9.2.2.1(a).

9.2.6.2. The deluge system is to contain fresh water through a pressurized system.

9.2.6.3. The discharge nozzles in the space(s) secured are to be positioned such that the spray is directed over the entire area containing the ammonia refrigeration machinery.

9.2.6.4. The pressurized system is to have two pumps, a tank with a capacity to maintain discharge for a period of 30 minutes to all of the nozzles simultaneously in the secured space(s), the tank to be fitted with adequate safety relief arrangements, pressure gauge(s), level control and level gauge.

9.2.6.5. Means are to be provided to automatically maintain the required pressure and the water level in the tank. In the event of low pressure or the low level, an audible alarm is to sound in the refrigeration machinery room, refrigeration cargo control room, if fitted, and the engine room.

9.2.6.6. The water deluge system is to be arranged to automatically start when the concentration of ammonia in the space surpasses 300 ppm.

9.2.6.7. The electrical equipment in the ammonia refrigeration compartment is to be to IP55 enclosure.

9.2.7. **Storage of Ammonia Cylinders**

9.2.7.1. A maximum of 140 kg (308 lb) of reserve ammonia may be stored in the refrigerating machinery space. Reserve ammonia in excess of this amount is to be stored in a separate storage space designed and constructed as pert the requisites of this Section, unless 9.2.7.7 is applicable.

9.2.7.2. Portable steel ammonia storage cylinders satisfying the requisites of Ch-3, 3.3.8 are to be stowed in an properly ventilated dedicated space.

9.2.7.3. The ammonia storage space is to conform to the requisites of 9.2.1.2, 9.2.2.3 and 3.2.5.

9.2.7.4. Access doors to the storage space are to be as per 9.2.2.1, except that two doors are not needed.

9.2.7.5. The storage space is to be provided with a mechanical ventilation system conforming to 9.2.3. Where the storage space is adjoining the refrigerating machinery space, a common ventilation system servicing both spaces may be accepted.

9.2.7.6. Means for secure stowage and handling of the steel storage cylinders are to be facilitated.

9.2.7.7. Where due to limited space, the provision of a separate storage space is impracticable, alternative solutions, such as location of the storage cylinders in the space containing the ammonia refrigeration machinery, will be subject to special considerations, provided that the water deluge system and the leakage detection system is extended to take account of the additional ammonia stored in the space.

9.3. Materials

9.3.1. Components in contact with ammonia are not to have copper, zinc, cadmium or alloys of these materials.

9.3.2. Components of rubber or plastic materials likely to be exposed to ammonia are not to be used.

9.3.3. Material for sea water cooled condensers is to be corrosion resistant to sea water.

9.4. Personnel Safety Equipment

9.4.1. An eye wash and shower unit are to be provided immediately outside of the refrigerating machinery room.

9.4.2. The safety equipment mentioned here under is to be provided and stored in a readily accessible, secured location outside of the refrigerating machinery room and is to be in addition to the equipment required by Part 7, Ch-3, Sec-4:

- At least two sets of ammonia protective clothing, including refrigerant gas mask, helmet, boots and gloves.
- One heavy duty adjustable wrench.
- At least two sets of fireman's outfits conforming to Part 7, Ch-3, Sec-4.
- Two or more power driven air compressors, to recharge breathing apparatus cylinders.
- Bottles of boric acid, vinegar and eye cups.

9.5. Safety Devices

9.5.1. A rupture disc is not to be used in series with the safety relief valve.

9.5.2. The discharge from safety relief valves on the ammonia side is to be led into the sea below the lightest water line or into the water dump tank near the bottom of the tank.

9.5.3. Ammonia refrigeration systems are to be provided with automatic air purging devices. The discharge from the purging devices is to be led overboard below the lightest water line or to the water dump tank such that the discharge opening is submerged at all times. The discharge pipe is to be of heavy grade where the connection is lead overboard.

9.5.4. Where condensers are cooled by fresh water which is re-circulated, in incidence of an ammonia leak, the fresh water system is to be equipped with pH meters to activate audible and visual alarms.

9.6. Piping Arrangements

9.6.1. Ammonia pipes are to have provision for contraction and expansion encountered in service. The use of metallic flexible hoses for this purpose will be subject to approval by IRS.

9.6.2. Where flexible bellows are proposed to be used in the ammonia refrigerant system, details and test data to show their aptness for the intended service are to be submitted.

9.6.3. Joints for piping conveying ammonia are to be butt welded, as far as feasible. For pipes up to 25 mm (1 in.) nominal diameter, socket welded joints may be accepted. Flanged joints are to be kept to a minimum and precautions are to be taken before disconnecting any such joints during repair and maintenance.

9.6.4. Piping for discharge of cooling sea water from the condenser is to be independent of other sea water piping systems and is to be led directly overboard without passing through accommodations or Category A machinery spaces.

9.6.5. Oil drains and oil traps are to be given at the low points of the refrigerant system. Gauge lines and branches to level controls are not to be in sites where oil is likely to accumulate.

9.6.6. Overboard discharges are to be as per Part 6, Ch-8, Sec-2, 2.5.8.

9.7. Electrical

9.7.1. **General**

Except as noted herein, conformation to Chapter 7 is required.

9.7.2. **Equipment and Installation in Hazardous Area**

Ammonia refrigerating machinery spaces and storage spaces are considered risky locations. Electrical equipment and wiring are not to be installed in such sites unless vital for operational purposes. Where electrical equipment is installed in the above spaces, the following conditions are to be met:

9.7.2.1. Electrical equipment operated in the event of ammonia leakage, such as vapor detection and alarm system, is to be intrinsically safe type.

9.7.2.2. Emergency lighting fixtures of explosion proof type are to be rendered in the above spaces. The switches for the lights are to be double pole type and situated outside these spaces.

9.7.2.3. Electrical motors for gas evacuation fans or ventilation fans, if used for the gas evacuation system, are not to be located in the fan ducts or inside the ammonia refrigerating machinery spaces. They are to be sited outside of the areas prone to risks.

9.7.2.4. For electrical equipment other than those referenced in 9.7.2.1 and 9.7.2.2, means are to be rendered for automatic de-energizing when the concentration of ammonia vapor in the space surpasses 300 ppm.

9.7.2.5. Cables in these spaces are to be armored and the penetrations are to be through gas tight fittings.

9.8. Instrumentation, Control and Monitoring

9.8.1. General

Instrumentation, control and monitoring for the ammonia refrigeration system are to be as per Chapter 8 and the following requirements.

9.8.2. Ammonia Vapor Detection and Alarm System

9.8.2.1. An ammonia vapor detection and alarm system is to be given for the following locations:

a) The refrigerating machinery spaces; one detector per 36 m^2 (387 ft^2) of the space floor area.
b) One detector in the exhaust duct of the refrigerating machinery space ventilation system.
c) The access corridors leading to the ammonia refrigerating machinery spaces.
d) One detector in the ammonia storage space.

9.8.2.2. If the concentration of ammonia exceeds 25 ppm, the detectors are to activate audible and visual alarms. In addition, if the concentration of ammonia reaches beyond 300 ppm, the detectors in the refrigerating machinery space are to cease the refrigerating plant and activate the gas evacuation system.

9.8.2.3. Additional ammonia vapor detectors set to provide an alarm in a constantly manned space if the ammonia concentration surpasses 500 ppm are to be provided in the discharge pipes from safety relief valves.

9.8.2.4. Note that the refrigerant leakage detection system required in 9.8.2.1 is in place of the system required by 8.5.

9.8.3. Instrumentation and Alarms

The alarms listed in Table 9.1 are to be given at the sites specified in 8.2.

Table 9.1: Instrumentation and Alarms

Item		Display	Alarm	Remarks
Condenser	Leakage of ammonia into cooling fresh water system	pH Meter	Leakage	Where condensers are cooled by fresh water
Water Dump Tank	Level	Level	Low	Automatic stop (Low pressure)
Ammonia Vapor Detection	Location mentioned in 9.8.2.2	Running	Exceed 25 ppm	
	Discharge pipes from safety relief valves		Exceed 500 ppm	
	Refrigerating plant automatic stop		Stop (300 ppm)	
	Activation of gas evacuation		Activation	

9.9. Tests and Inspections

9.9.1. Gas tightness of openings or doors referred to in 9.2.2 is to be substantiated by the attending Surveyor.

9.9.2. Electrical isolation of the refrigeration equipment at the set limit of 300 ppm of ammonia is to be demonstrated.

9.9.3. Ventilation air changes are to be validated by the attending Surveyor.

9.9.4. Satisfactory operational test of the emergency ventilation system is to be substantiated by the attending Surveyor.

9.9.5. Ammonia vapor detection and alarm system is to be demonstrated. This is to comprise of a demonstration of the required audible and visual alarms and stopping the refrigerating plant and activation of the gas evacuation system as per 9.8.2.

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

9.9.7. In the presence of the Surveyor, automatic de-energizing of non-intrinsically safe electrical equipment required in 9.7.2.4 is to be demonstrated.

CHAPTER 10 REFRIGERATED CARGO CONTAINER CARRIER

CONTENTS

10.1. General

10.1.1. Insulated containers are not considered as a part of the classed installation. However, as per 1.1.2.3 and 1.1.2.4, the requisites of this Section will apply for installations where the containers are supplied with cooled air from the vessel's refrigeration system.

10.1.2. Where requested, insulated containers will be validated as per the Rules for Certification of Cargo Containers.

10.2. Porthole Refrigerated Cargo Container Carrier

10.2.1. Design Considerations

10.2.1.1. The vessel's refrigeration system is to be designed, constructed and installed as per the requisites of this Section and other applicable requirements.

10.2.1.2. The arrangements are to be as per the applicable requisites of Chapter 4 where cargo cells are to be insulated.

10.2.1.3. Space heating of the cargo cells will be subject to special consideration.

10.2.1.4. Upon the air volume of each empty container connected to the system, the fresh air ventilation system and air circulation serving the containers is to be based. For frozen cargoes, air circulation for each connected container is to be 50 to 70 air changes per hour for fruit cargoes and 30 to 40 air changes per hour.

10.2.1.5. Fresh air ventilation for each container is to be minimum two (2) air changes per hour.

10.2.1.6. For monitoring CO_2 levels in each air cooler battery, means are to be facilitated.

10.2.2. Ducts and Couplings

10.2.2.1. Couplings, ducts and air cooler casings are to be airtight, as established by tests conducted as per 10.3.

10.2.2.2. The air flow to each connected container is to be within $\pm$5% of the design value where a container stack is supplied with cooled air from its own air cooler.

10.2.2.3. Insulation installed on the inside of ducts is to be of a type that is not affected by moisture and is resistant to abrasion. The properties required by 4.3.6 are also applicable.

10.2.2.4. Where couplings are pneumatically actuated, the compressed air piping, valves and fittings are to be in accordance with Part 6, Chapter-8 and are to be protected against freezing.

10.2.2.5. The compressed air system referred to in 10.2.2.4 is to incorporate moisture traps to ascertain the air supply is adequately dry to prevent ice formation when cargo cell temperatures are below 0°C (32°F).

10.2.2.6. So as to protect against icing, the outer surface of the coupling connections is to be insulated.

10.2.3. **Air Coolers**

When the total internal volume of all containers connected to a single air cooler surpasses 300 m^3 (10,593 ft^3), the air cooler coils are to be divided into at least two independent sections such that any one of them may be isolated without affecting the operation of the other. Alternatively, at least two independent air coolers are to be fitted.

10.2.4. **Instrumentation, Control and Monitoring**

Except as noted herein, refrigerating machinery plants and machinery spaces are to conform to the requirements in Chapter 8.

10.2.4.1. Temperature Monitoring

a) Delivery and return air ducts for each container are to be fitted with a thermometer. Where a group of containers is being served by one air cooler with common fans, the individual thermometers may be replaced by common thermometers for the delivery air.
b) Remote temperature monitoring of delivery and return air ducts is to conform to the requirements of 8.3.3.2, 8.3.3.3 and 8.3.4, except that the sensors in the delivery air ducts need not be connected to separate measuring instruments if the delivery air temperature is monitored locally.
c) The sensors are to be permanently connected to their instruments and secured against damage.

10.2.4.2. Monitoring

The display and alarms are to be provided as per Table 10.1 at the locations specified in Ch 8, 8.2.

Table 10.1 Instrumentation and Alarms

Item	Display	Alarm
Return air / Delivery air Temperature	Temperature	Deviation from set point
CO_2 Level in each Air Cooler Battery	Content	High

10.2.5. **Electrical**

The requisites in Chapter 7 are applicable.

10.2.6. **Automatic Control**

Where automatic control is provided for refrigerating machinery, conformation to Ch 8, 8.8, as applicable, is required.

10.3. Integral Refrigerated Cargo Container Carrier

10.3.1. **Design Considerations**

10.3.1.1. Where water-cooled condensers are provided, the cooling water flow rate is to be between 11 and 26 liters per minute.

10.3.1.2. Cooling water systems are to be as per Chapter 5, as applicable.

10.3.1.3. Cargo cells containing containers are to be rendered with ample air freshening capability to dissipate metabolic gas and also to ascertain that the cell temperature

does not surpass 10°C (18°F) above ambient while operating under the conditions specified in 3.2.2.1.

10.3.1.4. Where refrigerated cargo containers are taken in open hatch or hatchless cargo holds of a container vessel, the ventilation, bilge, hold temperature, etc. will be subject of special consideration.

10.3.2. **Instrumentation, Control and Monitoring**

Monitoring as per the following Table 10.2 is to be provided at a location specified in Ch-8, 8.2.

Table 10.2 Instrumentation and Displays

Item	Display
Power Supply (Monitoring)	Status
Compressor Running	Running
Defrost	Activate
Temperature in range	Temperature

10.3.3. **Electrical**

10.3.3.1. The requirements in Chapter 7 and the following are to be conformed to.

10.3.3.2. Plugs and receptacles of different electrical ratings are not to be interchangeable. They are to be in accordance with ISO standard 1496-2 or equipment compatible with ISO standard.

10.3.4. **Automatic Control**

Where an automatic control system is provided, conformation to Ch-8, 8.8 is required.

10.4. Tests and Inspections

10.4.1. **Porthole Refrigerated Cargo Container Carrier**

10.4.1.1. Measurements are to be done in the presence of the attending Surveyor during on-board trials to demonstrate the air circulation and ventilation rates are as per 10.2.1.4 and 10.2.1.5.

10.4.1.2. The air tightness required by 10.2.2.1 is considered satisfactory when the leakage rate does not surpass 0.5% of the total volumetric flow rate at the design pressure. Tests to establish conformation are to be conducted on the installed system in the presence of the attending Surveyor.

10.4.1.3. Tests to establish that the cooled air distribution is in conformation to 10.2.2.2 are to be conducted on the installed system in the presence of the attending Surveyor.

10.4.1.4. Compressed air lines connected to the coupling actuators referred to in 10.2.2.4 are to be tested to 1.5 times the design pressure.

10.4.1.5. The electrical test requirements in Ch-7, 7.7 are to be observed.

10.4.1.6. The alarms and displays required by 10.2.4 are to be substantiated for satisfactory operation at predefined set points.

10.4.1.7. In order to simplify shipboard testing, each type of air ducting system with couplings, an air cooler and circulating fans which are totally assembled at the manufacturer's plant may be tested before their installation onboard as per the following requirements:

a) The test is to be executed as per an approved test program in the presence of the Surveyor.
b) The k-values for the duct and cargo cells are to be established as per the requirements of 13.2.2.3.
c) Air leakage rate for the air distribution duct, couplings and air cooler casings is to be measured.
d) Air distribution in the air ducting system for a stack of containers is to be measured.
e) Air circulating fans are to be tested as per 13.2.1.1.

10.4.2. **Integral Refrigerated Cargo Container Carrier**

10.4.2.1. The design values required for conformation to 10.3.1.3 are to be depicted on the ventilation fan capacity curve and, by executing on-board trials in the presence of the attending Surveyor, the capacity curve is to be substantiated at the prevailing ambient conditions.

10.4.2.2. The electrical test requirements in 7.7 are to be observed.

10.4.2.3. The alarms and displays, where fitted for conformation to 10.3.2, are to be validated for satisfactory operation at the pre-defined set points.

10.4.2.4. Cooling water flow rate to the condensers is to be measured for conformation to13.1.7.

10.4.2.5. Air freshening ventilation fans for cargo cells are to be tested as per the applicable requirements in 13.2.1.1.

CHAPTER 11 REFRIGERATED EDIBLE BULK LIQUID TANKER

CONTENTS

11.1. General

11.1.1. The requisites of this Section are applicable to vessels defined in 1.3.14 requiring the notation referred to in 1.1.2.5 for the carriage of refrigerated edible bulk liquids.

11.1.2. The requisites of these Rules are applicable unless otherwise stated in this Section.

11.1.3. Due regard is to be given to the requisites of the Flag State and the Port State for the carriage and transportation of edible products.

11.2. Design Considerations

The material used is to be as per the requisites of Part 2 and the following:

11.2.1. Materials used for the construction of the cargo containment, the associated piping, pumps and valves are to be appropriate to bear the design service temperatures, pressures and are to be compatible with the products carried. Those materials which are incompatible with the edible products being transported are not to be used. Details of the materials are to be submitted for review.

11.2.2. The use of non-metallic materials for the cargo piping system will be the subject of special consideration. Accordingly, relevant details are to be submitted for review.

11.3. Hull Structure

For design and construction of the hull structure, refer to Part 3 and Part 4.

11.4. Cargo Containment System

11.4.1. Cargo Tanks

11.4.1.1. Cargo tanks, both independent and integral, are to be designed and constructed in accordance with the applicable requirements in Part 3. Integral tanks are also to comply with the requirements for integral tanks on chemical carriers in Part 8 – C, Chapter -2.

11.4.1.2. Independent pressurized tanks referred to in Ch-1, 1.3.15.4 are to be designed and constructed in accordance with Part 6, Chapter 10, as applicable.

11.4.1.3. The supports for the independent cargo tank(s) are to be designed as per the requirements of a recognized national or international pressure vessel design code to withstand the static and dynamic loads with liquid full cargo tanks.

11.4.1.4. The independent cargo tanks are to be fitted with anti-flotation devices, as necessary. The loads on the anti-flotation devices are to assume cargo tanks empty and the hold spaces flooded.

11.4.1.5. Where the cargo tanks are located in hold spaces, the void spaces are to be made accessible to enable inspection and examination of the containment pressure boundaries and insulation (if fitted).

11.4.2. Cargo Tank Protection

11.4.2.1. Cargo tanks are to be fitted with pressure/vacuum valves, as applicable, to prevent over or under pressurization. The discharges from the valves from a cargo tank may be led to another cargo tank, provided the cargo tanks are independent

of each other and it is not possible to pressurize or vacuum all the tanks simultaneously through a common system. Alternatively, the discharge from the cargo tank valves may be led to the hold bilges.

11.4.2.2. The setting of the cargo tank pressure/vacuum valve(s) is to be in accordance with Part 8–A and the arrangement is to be such that the valve(s) remain connected directly to the cargo tanks at all times, except during maintenance and repair.

11.4.2.3. For details of cargo tanks fitted with inerting facilities, refer to 11.5.3.2.

11.5. Cargo Loading and Unloading System

11.5.1. Cargo Piping

11.5.1.1. A permanently installed cargo loading and unloading system is to be fitted. There are to be a minimum of two pumps capable of taking suction from each cargo tank. Where submersible pumps are used, only one cargo pump per tank may be used, provided that an alternative method of pumping cargo is available onboard the vessel. This alternative method may be by means of pressurizing the cargo tanks.

11.5.1.2. For isolation of each cargo tank in the loading and unloading lines, means are to be provided.

11.5.1.3. Pipes, valves and the fittings in the cargo system are to conform to the requirements of Part 6, Chapter 8 & 9.

11.5.1.4. Cargo loading and unloading lines are to be secured against over pressurization by pressure relief valves. The discharge from the relief valves may be led to the cargo tanks.

11.5.2. Cargo Pumps

Where the cargo unloading is through cargo pumps other than submersible pumps, they are to be accessible for maintenance and repair.

11.5.3. Inert Gas System

Where cargo tanks are rendered with facilities to supply inert gas into the vapor spaces, the arrangements are to be as per the following requirements:

11.5.3.1. The location of the inert gas generating plant or the storage of the reserve inert gas is subject to approval by IRS.

11.5.3.2. The cargo tanks are to be fitted with pressure/vacuum valves to ascertain against over or under pressurization. The outlets from the pressure/vacuum valves are to be situated at least 5 m (16.5 ft.) from any openings and air intakes to the accommodation and service spaces.

11.6. Refrigeration System

11.6.1. The refrigeration machinery is to conform to the requirements of Chapter 3, as applicable.

11.6.2. Where a direct expansion system is used whereby the refrigerant is circulated through the cooling coils in the cargo tanks, the design of the coils are to be such as to ascertain that

there is no possibility of leakage of the refrigerant into the cargo. Details in this regard are to be submitted for review.

11.6.3. Where an indirect expansion system is used, the secondary coolant must not be detrimental to the cargo.

11.7. Ancillary Systems

11.7.1. **Cargo Tank Sounding Arrangements**

Cargo tanks are to be provided with means for assessing the liquid levels in the tanks. The system may be a permanently fixed or a temporary arrangement.

11.7.2. **Cargo Tank Ventilation**

Means for ventilating the cargo tanks during loading and unloading is to be fitted. For tanks supplied with inert gas, refer to 11.5.3.

11.7.3. **Hold Space Bilge Arrangement**

11.7.3.1. A permanently fixed bilge system is to be given for emptying out the hold space bilges. This system need not be independent of the Bilge system required by Part 6, Chapter 8 & 9.

11.7.3.2. Where the discharge from the cargo tank relief valves is led to the hold bilges, a bilge high level alarm is to be fitted to give an audible and visual alarm in the engine room or the bridge.

11.7.4. **Hold Space Ventilation Arrangements**

The hold spaces are to be rendered with adequate ventilation, where applicable.

11.8. Tests and Inspections

11.8.1. Tests and inspections of the refrigerating machinery and associated systems are to be as per the Ch-3, 3.13, or as applicable.

11.8.2. Tests and inspection of the vessel and its machinery, other than the refrigeration machinery, are to be as per the applicable Sections of the Rules.

CHAPTER 12 REFRIGERATED FISH CARRIER

CONTENTS

12.1. General

12.1.1. The requirements of this section are applicable to fishing vessels defined in 1.3.16 requiring the notation referred to in 1.1.1.6.

12.1.2. Unless otherwise stated in this Section, these Rules and Part 5, Chapter 14 of the Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length are applicable.

12.1.3. Due regard is to be given to the requisites of the Flag State and Port State for the carriage and transportation of edible products.

12.2. Design Considerations

Reference is to be made to the applicable requirements of this Chapter for design considerations.

12.3. Materials

Generally, the materials used are to be as per the requirements of Part 2 and the applicable sections of this Chapter.

12.4. Hull Structures

12.4.1. For design and construction of the hull structure, refer to the applicable parts of these Rules and the Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length, as applicable.

12.4.2. During unloading at sea where fishing vessels are moored against the mother vessels, fenders or other similar means for the protection of the shell plating may be required. Where such an arrangement is fitted, the shell plating in way of the protection is to be sufficiently strengthened.

12.5. Refrigerated Cargo Spaces

12.5.1. The refrigerated spaces are to conform to the applicable requirements of Chapter 4.

12.5.2. Equipment and fittings such as electric lights, etc. are to be properly protected to prevent damage during loading and unloading of cargo.

12.6. Refrigeration System

12.6.1. The refrigeration machinery is to conform to the requirements of Chapter 3, as applicable.

12.6.2. Where an ammonia refrigeration system is used, reference is to be made to Chapter 9, 9.1.3.

12.7. Refrigerated Sea Water Tanks (RSW Tank)

12.7.1. Each RSW tank is to be rendered with appropriate venting and sounding arrangements. The arrangements to assess the liquid levels in the tanks may be permanently installed or a temporary arrangement.

12.7.2. Where cooling coils are used in the tanks using ammonia as the refrigerant, refer to the requirements of 12.6.2.

12.7.3. Where an RSW tank is proposed to carry dry fish in bulk, in addition to the requirements for refrigerated spaces, the following arrangements are to be provided:

12.7.3.1. The tank is to be rendered with a bilge well and a permanent connection to the bilge system, unless the tanks are provided with independent bilge systems.

12.7.3.2. Arrangements are to be made for blanking off sea water piping.

12.8. Plate Freezers

12.8.1. Insulation and piping in plate freezers is to be secured from moveable parts of the system.

12.8.2. Flexible hoses in the system are to be of the armored type appropriate for the services intended.

12.8.3. Piping, including flexible hoses, is to conform to the requirements of 12.6.1 and 12.6.2.

12.9. Tests and Inspections

12.9.1. The tests and inspections of the refrigeration machinery and associated system are to be as per Chapter 3, 3.13, as applicable.

12.9.2. Tests and inspection of the vessel and its machinery, other than the refrigeration machinery, are to be as per the applicable Sections of these Rules or the Rules for Building and Classing Steel Vessels under 90 meters (295 feet) in Length, as applicable.

CHAPTER 13 TEST

CONTENTS

13.1. On Board Tests after Installation – (Commissioning)

13.1.1. Piping

13.1.1.1. All brine and refrigerant piping welded joints are to be hydrostatically tested to a pressure of 1.5 times the respective design pressure. As a substitute, 100 % non-destructive ultrasonic or radiographic testing of the welded joints may be conducted.

13.1.1.2. After accomplishing tests required in 13.1.1.1, and complete installing and assembling, but before the application of the insulation, a leak test is to be conducted on the refrigerant and brine systems using nitrogen or other apt gases at pressures not less than the design pressures of the respective systems.

Where defrosting with help of hot refrigerant gas is intended to be done, the design pressure for the leak test on the low pressure side is to be the same as the high pressure side.

13.1.1.3. The leak test may be executed using methods given below:

a) By submerging the refrigerant and brine piping and equipment besides applying the pressure referred to in 13.1.1.2.
b) By building up an initial pressure of 0.5 to 1.0 bar (0.5 to 1.0 kgf/cm^2, 7 to 14 psi) in the refrigerant and brine piping systems and checking for leaks at the pressure by soapy water test, tracer, or detectors. If no leaks are detected or leaks found are dealt with satisfactorily, the pressure is to be increased gradually to the respective design pressures of the systems. The pressure is to be maintained for a pre-determined period and pressure deviations are to be recorded.
c) Subject to the satisfaction of the attending Surveyor, other alternative, effective methods similar to those described above are to be taken.

13.1.1.4. After completion of the above-mentioned tests, the refrigerant piping systems are to be flushed with dry nitrogen to ascertain cleanliness and dryness.

13.1.2. Before charging with refrigerant, the entire refrigeration system is to be evacuated using vacuum pumps.

13.1.3. After all the above mentioned pressure tests are done, all refrigerant and brine pipes are to be examined under working pressure.

13.1.4. The refrigeration plant is to be operated to demonstrate its ability to modulate the refrigeration capacity in single and multiple compressor operation with all feasible variations in the cross over connections that can be made with condensers, compressors and evaporators.

13.1.5. Validate operation of thermostats, solenoid valves, bypass valves, expansion valves, evaporator brine line valves and condenser water regulators and other such similar devices.

13.1.6. For satisfactory operation, plant safety valves and other similar safety devices are to be validated.

13.1.7. Cooling water flow rates through the condenser are to be measured to determine that the velocities do not go beyond the maximum design values while operating with the main cooling water pump and then the standby pumps.

13.1.8. The satisfactory operation of the automatic or manual oil refrigerant separation system is to be substantiated to ascertain that separated oil is returned to the compressors such that the oil levels between the compressors are balanced.

13.1.9. After initial startup, for satisfactory operation, the refrigeration monitoring system and the automatic control system, where fitted, is to be validated.

13.1.10. Effective operation of the refrigerant leakage detection system is to be demonstrated.

13.2. Performance Test

13.2.1. Air Circulation and Fresh Air Ventilation

13.2.1.1. Testing of all fans for air circulation and fresh air ventilation of cargo spaces is to be done at the full rated speeds of volumetric flow rates referred to in Sec4, 4.5. The testing is to include measurements of pressure difference across the fans and power consumption. The anemometer or other similar measuring devices may be located on the suction side of the cargo hold. To the satisfaction of the attending Surveyor, these measuring devices are to be calibrated.

13.2.1.2. The air circulation distribution pattern in the refrigerated cargo spaces is to be inspected.

13.2.1.3. The air distribution measurement referred to in 13.2.1.2 is to be conducted to substantiate the design values specified by the manufacturers and to ascertain that there are no areas of inadequate air flow.

13.2.2. Refrigeration Machinery and Insulation Test

13.2.2.1. General

The following refrigeration machinery and insulation tests are to substantiate that the plant has ample refrigeration capacity as required by Sec 3, 3.2.2 relative to the insulation and other heat loads to attain and maintain the minimum design temperature, that will be the basis of the notations referred to in Ch 1, 1.1.

13.2.2.2. Pull Down Test

All openings to the cargo spaces including the air freshening vents are to be closed upon completion of the commissioning test referred to in 13.1.

The refrigerated cargo hold spaces are to be warmed up to ambient atmospheric temperature with the help of running air circulation fans and brine pumps, if fitted.

The refrigeration plant is to be initiated and run at full capacity under automatic control using all compressors and set at maximum design condensing temperature. The refrigeration machinery should continue to run until the minimum design temperature in all cargo spaces has been achieved. The operation of the refrigeration machinery is to be monitored to ascertain satisfactory operation within design parameters.

13.2.2.3. Heat Balance Test

Upon achieving the minimum design temperature of the refrigerated spaces, after the test specified in 13.2.2.2, a heat balance test is to be initiated by switching one compressor to manual and remainder switched off and allowing

the temperature to stabilize at approximately the minimum design temperature or at least minus 20°C (68°F) and held at these temperatures for an adequate period of time, generally about 24 hours, to remove the residual heat in the insulation and attain a balanced condition.

The condition is considered to be balanced when the mean temperature in each hour the refrigerated cargo space does not vary by more than ±0.5°C (±1°F). The balanced condition should be planned to be attained during the time of day when the outside temperature is as constant as possible. The collection of data is to be taken initially every six (6) hours and every hour for the last six (6) hours during stabilization period.

For this test, at least the following data are to be recorded:

a) The outside temperatures of the shell, bulkheads and decks enclosing the refrigerated cargo spaces.
b) The internal temperatures of the cargo spaces.
c) The discharge and suction pressure of the compressors.
d) The actual voltage and amperage of the compressor electric motor.
e) Heat inputs to the refrigerated spaces from lighting fixtures, fan motors, heat tracing on drain pumps, etc.
f) The rate of cooling water flowing through the condensers.
g) The inlet and outlet temperatures of the condenser cooling water.
h) Based on the heat balance test mentioned above, upon achieving stabilized temperatures, calculations of the k values are to be conducted by the yard/builder and those need to be submitted to IRS for review. For these calculations, the air cooler overall heat transfer coefficient at the design conditions is to be taken equal to that measured during the heat balance test. Similarly, the condenser overall heat transfer coefficient at the stated maximum sea water temperature is to be taken equal to that measured during the heat balance test.

13.2.2.4. Refrigerated Port Hole Type

A full functional test of all refrigerated cargo spaces may not be required if an operational test equivalent to that described herein is executed onboard with minimum one cell of containers installed and the following requirements are satisfied in case of container carriers described in Sec 10, 10.2:

a) Cooling air to the containers is supplied exclusively by air ducts tested as per Sec 10, 10.4.
b) The builder demonstrates by calculating, using data obtained during testing described above, to show that the refrigerating machinery has adequate capacity.
c) It is to be demonstrated that the cell conditioning, if fitted, is adequate to maintain the cell at a temperature which is in excess of the minimum design temperature of the structural steel.

13.2.2.5. Insulation Test

After the cargo spaces have been stabilized for the heat balance test in 13.2.2.3, the external surfaces of the shell, decks, bulkheads, doors and other opening covers, as well as duct, pipe and cable penetrations are to be checked for undue condensation or frost pinpointing voids and thermal bridges in the insulation.

13.2.2.6. Temperature Rise Test

For the temperature rise test, the refrigerating machinery is to be ceased and all of the heat input sources shut off after stabilization, as in 13.2.2.3, and at least the underlying data are to be recorded once per hour over a six-hour period.

a) The outside temperature of the entire shell covering up the refrigerated cargo space such as ambient, sea water, tanks, engine room.
b) The internal temperature of the cargo space:
    i. The test is to be done at the time of the day when the outside temperature is as constant as possible.
    ii. The calculations of the k values is to be conducted by the yard/builder and together with a drawing showing precise locations and position of the values recorded for this test are to be submitted to IRS for review.

13.2.2.7. Defrosting Test

Upon satisfactory completion of the heat balance test and temperature rise test, the cooler batteries are to be defrosted to demonstrate the ability to totally defrost. The Surveyor is required to substantiate that the system for removing defrosts water is operating satisfactorily.

13.2.2.8. Multiple Compartment Temperature Test

Where the specified design parameter requires multiple temperature configurations, a test is to be conducted to demonstrate this capability for the refrigerated spaces.

13.2.2.9. Heating Capacity Test

Where the specified design parameter requires a heating capacity to be available for the refrigerated compartments, a test is to be conducted to demonstrate the capability of the heating system.

13.2.2.10. Automatic Control System

Where automatic control systems are fitted, the tests referred to under 13.2.2.2, 13.2.2.6, 13.2.2.7 and 13.2.2.8 are to be executed using the control system.

13.2.3. **Testing is to cover the following items:**

a) Verification of control, alarm and safety systems.
b) Simulation tests for failure of refrigeration equipment, to verify correct functioning of alarms and systems in service.
c) Verification of accuracy, calibration and functioning of temperature control for refrigeration systems.

13.2.4. **Trials**

Acceptance trials, as stipulated in this Section, are to be conducted. It is to be demonstrated that the provision store or air-conditioning refrigerating system capacity meets the design duty. As far as is practicable, the trials are to represent the operating conditions that will be encountered in service. For example, the condenser cooling water flow should be restricted so that the compressor discharge pressure is at the design value.

CHAPTER 14 SPARE PARTS

CONTENTS

14.1. General

14.1.1. It is suggested that adequate spares, along with the tools vital for maintenance, or repair, be executed. As per the design and intended service, the spares are to be determined by the Owner. It is the responsibility of the Owner to do the maintenance of the spares.

14.1.2. The spare parts for refrigerating plant as given below in Table 14.1 are to be provided at accessible places on board.

Table 14.1: Spare Parts

Items	Numbers Required	Remarks
Fan impeller for air circulation	One for each size	
Compressor piston with piston rod or connecting rod	One complete set for one cylinder each size	Complete set
Main bearing brasses for compressor	One complete set	
Compressor suction and delivery valves	One complete set, each size	Complete set with valve chest, spring, etc.
Crank shaft airtight seals for compressor	One set for each compressor	Where crank case is subject to refrigerant pressure
Crank shaft coupling bolts	One complete set for one coupling, each size	
Motor shafts coupling bolts and washers	Do	
Suction filter	One	
Expansion valve	One for each size	
Lubricating oil pump and filter	One set	Complete set
Suction and delivery valves for cooling water, air and brine pumps	One set for each size	
Driving belt	One set for each size	
Pipe bends, pipes, flange couplings and screw appliances	Some for each size	
Valves, cocks, flange couplings and fittings	Do	
Bolts, nuts, studs, packings and joint rings	Some for each size	
Pressure gauge	One complete set	
Thermometers (indicating the degree of each kind)	5% of total number of each kind	Not less than two for each kind
Temperature sensors for remote reading temperature measuring	5% of total number	Not less than one of each type used
Standard thermometer	Not less than two	To be used for the temperature in necessary range
Battery for electric thermometer	One	
Safety valve or relief valves intended for primary refrigerant	Two for each size	Complete set
Rupture discs	Six for each size	
Hydrometer	One	Where brine is the cooling medium
Refrigerant leak detector	One set	
Float regulator assembly	One set for each size	