



RULES FOR
CLASSIFICATION OF
SHIPS

NEWBUILDINGS

SPECIAL SERVICE AND TYPE
ADDITIONAL CLASS

PART 5 CHAPTER 10

SHIPS FOR CARRIAGE OF REFRIGERATED CARGOES AND CONTAINERS

JULY 2007

*This booklet includes the relevant amendments and corrections
shown in the July 2008 version of Pt.0 Ch.1 Sec.3.*

CONTENTS	PAGE
Sec. 1 General Requirements	5
Sec. 2 Materials	7
Sec. 3 Refrigerating Plant	9
Sec. 4 Refrigerated Chambers. Construction, Insulation and Instrumentation	15
Sec. 5 Controlled Atmosphere	18
Sec. 6 Tests.....	22

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CHANGES IN THE RULES

General

This booklet is a reprint of the previous edition and apart from clarifications of text and the inclusion of amendments and corrections, published in the January 2007 edition of Pt.0 Ch.1 Sec.3, no other changes have been made. The booklet supersedes the January 2003 edition of the same chapter.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made in the existing rule text.

Comments to the rules may be sent by e-mail to rules@dnv.com

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CONTENTS

SEC. 1 GENERAL REQUIREMENTS	5	C. Protection against Moisture	16
A. Classification.....	5	C 100 Design and workmanship.....	16
A 100 Application.....	5	D. Air Circulation System and Drainage, Air, Sounding and Water Pipes	16
A 200 Class notations	5	D 100 Air circulation system	16
A 300 Certification of control and monitoring system	5	D 200 Drainage.....	17
B. Operational Performance.....	5	D 300 Air, sounding and water pipes	17
B 100 General	5	E. Equipment for Temperature Measurements. Gas Indication Equipment	17
C. Documentation	5	E 100 Equipment for temperature measurements	17
C 100 Plans and particulars	5	E 200 CO ₂ indication equipment	17
SEC. 2 MATERIALS.....	7	E 300 Oxygene indication equipment	17
A. Hull Structures	7	SEC. 5 CONTROLLED ATMOSPHERE.....	18
A 100 Definitions.....	7	A. General.....	18
A 200 Properties	7	A 100 Application.....	18
A 300 Allowable stresses.....	7	A 200 Class notations	18
B. Refrigerating Plant	7	A 300 Basic assumptions	18
B 100 General	7	A 400 Documentation	18
C. Refrigerated Chambers	8	B. Arrangement and System	19
C 100 Insulation.....	8	B 100 General	19
SEC. 3 REFRIGERATING PLANT	9	B 200 Access	19
A. Design Criteria	9	B 300 Piping systems	19
A 100 General	9	B 400 Ventilation of adjacent spaces	19
A 200 Redundancy requirements.....	9	B 500 N ₂ release prealarm	20
A 300 Capacity	9	C. Operational Performance.....	20
A 400 Refrigerants	9	C 100 Atmosphere quality.....	20
A 500 Design pressures	10	C 200 Required capacities	20
B. Machinery	10	D. Nitrogen Generator. Carbon Dioxide Scrubbers	20
B 100 General	10	D 100 Nitrogen generator	20
B 200 Machinery in refrigerated chambers and cooling/freezing tunnels	11	D 200 Carbon dioxide scrubbers	20
B 300 Refrigerant circuit	11	E. Electrical Installations	20
B 400 Cooling water arrangement. Condenser and brine cooler capacity	11	E 100 General	20
B 500 Refrigerated seawater tanks (RSW).....	12	E 200 Cable penetrations.....	20
B 600 Compressors.....	12	F. Instrumentation	20
B 700 Vacuum operation	12	F 100 General	20
C. Electrical Installations	12	F 200 Gas monitoring.....	20
C 100 General	12	F 300 Control of cargo chamber atmosphere.....	21
D. Accessories	12	F 400 Alarm and monitoring.....	21
D 100 Pipes and tubes.....	12	G. Instruction Manual. Personnel Protection Equipment ..	21
D 200 Pressure vessels and heat exchangers	12	G 100 Instruction manual	21
D 300 Brine piping system and vessels	13	G 200 Personnel protection equipment.....	21
D 400 Safety valves and discharge system.....	13	SEC. 6 TESTS	22
D 500 Oil separators, filters and driers	13	A. Pressure Tests of Components	22
D 600 Temperature, pressure and level indication	14	A 100 General	22
E. Instrumentation and Automation.....	14	A 200 Test pressures.....	22
E 100 General	14	B. Pressure Tests after Assembly	22
E 200 Automatic control	14	B 100 General	22
E 300 Monitoring	14	B 200 Pressure tests after erection on board.....	22
SEC. 4 REFRIGERATED CHAMBERS. CONSTRUCTION, INSULATION AND INSTRUMENTATION	15	B 300 Drying of the refrigerating plant.....	22
A. Arrangement and Design.....	15	C. Function and Capacity Testing of the Completed Installation.....	22
A 100 General	15	C 100 General	22
A 200 RSW tanks	15	C 200 Refrigerating machinery, operational test.....	22
B. Insulation Construction	15	C 300 Thermometers. Gas indicating equipment	23
B 100 General	15	C 400 Air circulation and air renewal systems.....	23
B 200 Insulation on sides, bulkheads and below deck	15	C 500 Chamber tightness test	23
B 300 Insulation on tank top and 'tween decks	15	C 600 Insulation and heat balance test	23
B 400 Insulated hatches and doors	15	C 700 Verification of refrigerating capacity.....	23
B 500 Protection of cooling grids and refrigerant pipes. Pipe and other penetrations.....	16	D. Testing of CA installations	23
B 600 Lining and protection of insulation	16	D 100 General	23
		D 200 Instrumentation	23

SECTION 1 GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 The rules, as relevant, in this chapter apply to ships with refrigerating plants for

- carriage of refrigerated dry cargo
- carriage of fruit or vegetables under a controlled atmosphere
- cooling down or freezing catches of fish or
- carriage in bulk of refrigerated fruit juices and similar liquid cargoes

when a class notation in 200 is requested.

102 The safety and environmental requirements of this chapter, identified by being printed in **bold italics**, apply to ships as specified in Pt.4 Ch.1 Sec.3 A600.

A 200 Class notations

201 Ships designed, built, equipped and tested under the supervision of the Society in compliance with the requirements of this chapter may be given one of the additional class notations in 202 to 207.

202 Ships built mainly for carriage of refrigerated dry cargo may be given the class notation **Reefer(...°C/...°C sea)** (lowest chamber temperature/maximum seawater temperature).

203 Dry cargo ships having a partial cargo carrying capacity for refrigerated cargo or fishing vessels with refrigerating plant for cooling or freezing catches of fish, may be given the class notation **RM(...°C/...°C sea)** (lowest chamber temperature/maximum seawater temperature).

204 Ships intended for transport of refrigerated containers with cooling provided by the ship's refrigerating plant may be given the class notation **RM Container**.

205 Ships built and fully equipped for carriage of bananas and fruit in general under a controlled cargo chamber atmosphere in at least 50% of the ship's total refrigerated cargo chamber volume may be given the class notation **CA**.

206 Ships built and equipped for carriage of bananas and fruit in general under a controlled cargo chamber atmosphere in at least 50% of the ship's total refrigerated cargo chamber volume except that a nitrogen generating unit and possibly parts of the alarm and monitoring equipment have not been permanently installed may be given the class notation **CA(port.)**.

207 Ships built for bulk transport of fruit juices and similar cargoes in refrigerated tanks may be given the class notation **Refrigerated Fruit Juice Carrier** provided they also comply with relevant parts of the rules in Ch.4.

A 300 Certification of control and monitoring system

301 The control and monitoring systems for:

- cargo hold temperature system

shall be certified according to Pt.4 Ch.9.

B. Operational Performance

B 100 General

101 The ship shall be designed, arranged and equipped to make it suitable for cooling down and/or carrying cargoes,

freezing catches of fish etc. as relevant according to the design operating conditions specified by the builders and subsequently to be stated in the Appendix to the classification certificate. The builders' and possible subcontractors' specifications of the ship's operational performances and abilities will together with the specific requirements of this chapter be used as basis for assignment of class.

C. Documentation

C 100 Plans and particulars

101 The following plans and particulars shall be submitted for approval:

- 1) an arrangement plan of the insulated chambers with cross-sectional and plan views showing:
 - the position of the chambers in the ship
 - the purpose of adjacent rooms
 - adjacent bunker tanks with indications of their maximum temperature
 - the dimensions and spacing of frames, girders, and other details which project into the insulation or the chambers
 - pipes, ducts etc. which lead through the chambers.
- 2) a plan showing access and escape arrangements for chambers and air cooler rooms
- 3) insulation drawings for chambers and brine rooms including:
 - a list specifying the insulation materials to be used (samples may also be required) and application and production procedures when applicable
 - insulation with thicknesses and details of fastening
 - internal lining of the chambers and brine rooms
 - suspension and fastening of refrigeration pipes etc.
 - passages for the refrigeration pipes through the bulkheads and decks
 - insulation of doors, hatches, cargo ports, etc.
- 4) arrangement plans of air cooler rooms, air ducts and air distribution systems within the chambers, air coolers, and fans with specifications of the dimensions and cross-sectional area of the ducts
- 5) specifications of the paint system or other corrosion protection of structural steel and pipes
- 6) piping and instrumentation diagrams for refrigerant and auxiliary systems
- 7) RSW piping diagram
- 8) specification of the defrosting procedure
- 9) a plan showing the position of the sensors for remote and local thermometers, CO₂ sensors and refrigerant leakage detection sensors
- 10) specifications and drawings of detection equipment for temperature, CO₂ and refrigerant leakage
- 11) a plan showing the position of the drain, air and sounding pipes and thermometer tubes with their protection and insulation
- 12) cargo chamber bilge and drain arrangement. Liquid-sealed traps and check valves
- 13) an arrangement plan of the refrigerating machinery room

with specifications of the ventilation system

- 14) a cross-sectional plan of the compressors
- 15) a plan of the crankshaft of the compressors
- 16) a plan of the condensers, brine and rsw coolers, air coolers, oil separators, liquid receivers and other pressure vessels
- 17) a plan of the plate freezers and tunnels
- 18) an arrangement plan of process areas etc. where R717 freezing/cooling equipment is located showing also accesses, emergency escapes and ventilation system
- 19) electrical wiring diagram for the refrigeration installation
- 20) a program for function, insulation and capacity testing after completion
- 21) a calculation procedure, based on data recorded during the balance test, to verify the refrigeration capacities at all design operating conditions.

Documentation requirements for insulation and lining of RSW tanks are covered by Ch.6.

102 The following particulars shall be submitted for information:

- detailed specification of the refrigerating installation. All design operating conditions and all operational performances and abilities of the installation shall be given
- the operation manual for the refrigeration installation

- the specified overall heat transfer coefficient of the insulation, (with the areas to be used for this purpose)
- calculation of the refrigeration loads at all design operating conditions
- capacity curves/capacity data for the compressors, fans, pumps, condensers, brine and RSW coolers and air coolers
- calculations, based on data recorded during the balance test, to verify sufficient refrigeration capacity at all design operating conditions.

103 For general requirements for documentation of instrumentation and automation, including computer based control and monitoring, see Pt.4 Ch.9 Sec.1.

The following control and monitoring systems shall be approved by the Society:

- cargo cooling system
- cargo hold temperature system
- carbon dioxide indication equipment
- refrigerant leakage detection system.

For requirements for documentation, see Pt.4 Ch.9.

104 *For ships without class notations according to this chapter (see Pt.4 Ch.1 Sec.3 A600), documentation covering the applicable safety requirements shall be submitted.*

105 Documentation required for class notations **CA** and **CA (port.)** is given in Sec.5 A400.

SECTION 2 MATERIALS

A. Hull Structures

A 100 Definitions

101 Symbols:

t_s = steel temperature, defined as the temperature of the material when the refrigerated chamber is at its lowest service temperature and the ambient temperature is 0°C. Where structures protrude into refrigerated spaces (e.g. rounded deck plates at hatch corners, deep girders etc.) and are insulated on both sides, the temperature t_s in such structures shall not be taken higher than 10°C above the refrigerated chamber temperature.

The temperature t_s in web plates may be taken as the average of the two flanges.

σ_{tv} = tensile stress in transverse girder flanges.

$$= \sigma_t + \sigma_b$$

σ_{lt} = total longitudinal tensile stress in plating or girders.

$$= \sigma_l + \sigma_t + \sigma_b$$

σ_l = longitudinal tensile stress in hull girder.

In the deck plate at a hatch corner the longitudinal stress σ_l shall be multiplied by 2.

$$= 135f_2 \frac{Z_n + Z_a}{Z_n}$$

f_2 = stress factor as defined in Pt.3 Ch.1.

Z_n = vertical distance in m from the baseline or deckline to the neutral axis of the hull girder, whichever is relevant.

Z_a = vertical distance in m from the baseline or deckline to the point in question below or above the neutral axis, respectively.

In the deck plate at a hatch corner the longitudinal stress σ_l shall be multiplied by 2.

σ_t = thermal stress.

$$= 50 \frac{t_s}{(-30)} \text{ N/mm}^2$$

σ_b = local tensile bending stress in girders in N/mm².

A 200 Properties

201 The properties of steel materials in hull structural members at temperatures t_s between -5°C and -40°C shall be as given in Table A1. Structural elements below -40°C shall be specially considered.

202 The requirements are based on the assumption that structural details are carefully designed. Also in 'tween decks the hatch openings and smaller openings shall have well rounded corners.

203 For steel structures completely on the chamber side of the insulation t_s may normally be taken as the chamber temperature.

For structure outside of the insulation, material grades may normally be selected according to Pt.3 Ch.1.

A 300 Allowable stresses

301

Local tensile stress, $(\sigma_t + \sigma_b) \leq 190 f_1 \text{ N/mm}^2$.

Total longitudinal stress, $\sigma_{lt} \leq 225 f_1 \text{ N/mm}^2$.

Equivalent stress, $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 235 f_1 \text{ N/mm}^2$.

Table A1 Hull materials for refrigerated cargo vessels		
Structural members	σ_{lt} or σ_{tv} N/mm ²	Required minimum grade of steel.
Plating and longitudinal girders in strength deck (upper continuous deck).	$> 160 f_1$ $\leq 160 f_1$	NVE for $-30^\circ\text{C} \leq t_s \leq -10^\circ\text{C}$. NVD for $t_s > -10^\circ\text{C}$. ¹⁾ NVE for $t_s \leq -20^\circ\text{C}$. NVD for $t_s > -20^\circ\text{C}$. ¹⁾
Plating and longitudinal girders in decks below strength deck. Flanges of stringers at ships sides. Flanges of transverse girders in strength and tween decks and at sides. Girder flanges in hatch covers.	$> 160 f_1$	NVE for $t_s \leq -20^\circ\text{C}$. NVD for $t_s > -20^\circ\text{C}$.
	$100 - 160 f_1$	NVE in plating and longitudinal girders along hatches (including deck plating at hatch corners and above pillars) for an area extending transversely not less than 1.5 m outside hatches, when $t_s < -20^\circ\text{C}$. NVD when $t_s \geq -20^\circ\text{C}$. NVD elsewhere.
	$< 100 f_1$	NVD in plating and longitudinal girders along hatches (including deck plating at hatch corners and above pillars) for an area extending transversely not less than 1.5 m outside hatches, when $t_s < -20^\circ\text{C}$. NVB when $t_s \geq -20^\circ\text{C}$. NVB elsewhere.
Web plates in transverse girders in decks and at sides, stringers at sides and girders in hatch covers, where shear stress exceeds $60 f_1 \text{ N/mm}^2$.		NVD when $t_s \leq -20^\circ\text{C}$. and thickness $t \geq 10 \text{ mm}$
		NVB when $t_s > -20^\circ\text{C}$. NVB when $t_s \leq -20^\circ\text{C}$ and thickness $t < 10 \text{ mm}$

1) For $t_s < -30^\circ\text{C}$ minimum impact energy 27J at a temperature 10°C below t_s

B. Refrigerating Plant

B 100 General

101 The materials are generally to comply with the requirements specified in Pt.2, Pt.4 Ch.6 Sec.2 and Pt.4 Ch.7 Sec.2.

Other suitable material specifications will be considered for approval in each individual case. The materials shall be tested in accordance with the regulations for material testing given in Pt.2.

For a closed refrigerating circuit using refrigerants of Group 1 or R717 and with a lowest design evaporating temperature of -41°C or warmer:

— rolled steel plates will be accepted in accordance with Pt.2 Ch.2 Sec.2 B. A grade impact tested at 0°C (or colder) shall be selected

— steel pipes and fittings will be accepted in accordance with Pt.2 Ch.2 Sec.4 B.

In such systems for lower design evaporating temperatures and for other Group 2 refrigerants rolled steel plates and steel pipes and fittings shall comply with Ch.5.

Possible sub-cooling of the liquid in connection with accidental blow down need not be taken into account when deciding the design temperature.

For refrigerating systems on gas carriers where the cargo is used as refrigerant the materials and the design temperature shall be in accordance with Ch.5.

102 The materials shall be corrosion-resistant to the refrigerant and the compressor oil and to the combination of the two.

103 *The following materials and refrigerants shall not be combined:*

- 1) *Copper with ammonia.*
- 2) *Magnesium with fluorinated hydrocarbons.*
- 3) *Zinc with ammonia and fluorinated hydrocarbons.*

- it shall be resistant to decay and be chemically neutral
- it shall have high insulating properties. When insulation materials with low resistance against moisture transmission and air movements are used, the integrity and completeness of the lining and vapour barrier shall be given special attention.

C. Refrigerated Chambers

C 100 Insulation

101 The insulation material shall have the following qualities:

- it shall not absorb and give off odours or gases which may affect the cargo
- it shall have good mechanical resistance to vibrations and deformations at the actual temperatures. Disintegration and structural changes shall not occur

102 The insulation material shall be durable at working temperatures and temperature variations. Material placed on surfaces which may be exposed to direct sunshine, on tanks which are heated, etc. shall withstand at least 100°C without being destroyed. Use of wood will be specially considered.

103 *Organic foams shall be of a flame-retarding quality, i.e. low ignitability and low flame-spread properties. Testing shall be carried out in accordance with a recognized standard, e.g. DIN 4102.IB2, or equivalent. The test method chosen shall be suitable for the type of foam in question.*

104 A foam “in-situ” type of insulation may be used when full details of the process have been approved.

SECTION 3 REFRIGERATING PLANT

A. Design Criteria

A 100 General

101 The refrigerating plant with machinery and all components and accessories is in every respect to function satisfactorily at the following conditions:

- permanent list: 15°
- rolling: ± 22,5°
- trim and pitch according to Table A1.

Table A1 Trim and pitch					
Trim and pitch		Length of ship (m)			
		< 100	< 200	≤ 300	> 300
Trim ¹⁾	Aft	5°	2.5°	1.5°	1°
	Forward	2°	1°	0.5°	0.3°
Pitch ^{1) 2)}		±10 °	±7.5 °	±5 °	±3 °
1) Other values may be accepted if justified by calculations for the actual ship.					
2) From even keel or designed rake of keel.					

102 The refrigerating plant shall be designed for one or more of the following operating conditions:

- carriage of frozen cargo at -20°C or colder
- freezing down from ambient to -20°C or colder a specified quantity of fish pr. 24 hours
- carriage of fruit in general at approximately +4°C to 0°C
- carriage of bananas at approximately +12°C
- other specified operating conditions.

The design operating conditions will be specified in the Appendix to classification certificate.

103 Wherever this chapter includes requirements to brine systems or components these requirements are as far as relevant also applicable in case of other secondary systems e.g. systems using glycol and water mixtures.

A 200 Redundancy requirements

201 For ships with class notation **Reefer** at least two complete refrigeration units shall be fitted. Each unit is at least to consist of compressor with drive motor and lubricating oil pump if fitted, condenser, brine cooler, if relevant, and necessary piping and valves for running the units independently of each other.

The arrangement shall be such that each unit may be connected to any one chamber.

202 For ships with class notation **RM** at least two complete refrigeration compressors with drive motors shall be fitted.

203 In the case of separate refrigeration plants fitted for individual chambers or groups of chambers, the question of standby units required will be subject to special consideration.

204 With indirect cooling and with circulation of the refrigerant by pumps, a standby pump, arranged for immediate use, shall be installed. The capacity of the standby pump shall not be less than that of the largest of the other pumps, and it shall not be arranged for other purposes on board.

205 When two or more refrigeration units, refrigeration compressors, cooling water pumps, brine pumps, etc. are required for redundancy purposes these shall have separate electrical supply.

A 300 Capacity

301 With any one of the units or compressors required by 201, alternatively 202 being out of operation, the available capacity shall be sufficient to maintain the chamber temperature at all design operating conditions. In case of forced air circulation, the chamber temperature is defined as:

- delivery air temperature in the case of temperatures above 0°C
- return air temperature in the case of temperatures below 0°C

302 The maximum seawater temperature for which the plant is designed is as specified in the class notation. The average outside air temperature for a 24-hour period shall be taken as 3°C above the specified seawater temperature. The air humidity is assumed to be 70%.

Guidance note:

Typical values for maximum seawater temperatures:

Tropical waters, open sea	30°C
Tropical coastal waters	32°C
The Persian Gulf	35°C
The Mediterranean	27°C
The North Sea	20°C

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 For fruit in general and bananas the total capacity of the refrigeration plants shall be sufficient to lower the temperature of the entire cargo from the average day temperature of the loading port to the specified transporting temperature within a reasonable period of time.

Guidance note:

The capacity requirement of 303 is considered to be complied with if an excess capacity of minimum 33% relative to that required to maintain the cargo at specified chamber temperatures during the carriage is available, i.e. with 4 equal units fitted, 3 must fulfil the capacity requirement in 301.

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A 400 Refrigerants

401 Group 1:

Refrigerants in this group are normally nonpoisonous, but all of them can be poisonous when decomposed by a flame or by a hot surface. These refrigerants are heavier than air, give no odour warning and will give a dangerous atmosphere by displacement of air. The lack of odour and the high density make these refrigerants particularly dangerous with regard to suffocation.

R22 (monochlorodifluoromethane)	CHF ₂ Cl
R134a (1,1,1,2-tetrafluoroethan)	CH ₂ F-CF ₃

402 Group 2:

Refrigerants in this group are particularly poisonous. R717 is lighter than air and is flammable in very high mixing ratios with air. A very high ignition energy is then required to start a fire.

R717 (ammonia)	NH ₃
----------------	-----------------

403 The use of other refrigerants will be given special consideration.

A 500 Design pressures

501 The scantlings of the various parts of the refrigerating plant shall be based on the pressures specified in Table A2.

Table A2 Design pressures for refrigerating plant		
Refrigerant	Minimum design pressure bar	
	HP side of system	LP side of system
R22	22	15
R134a	14	11
R717	22	15

502 If refrigerants other than those specified in Table A2 are used, the design pressure is subject to approval in each individual case. It may, in general, be assumed to be equal to the vapour saturation pressure of the refrigerant at 55°C and 45°C on the HP and LP sides, respectively.

B. Machinery

B 100 General

101 All parts of the machinery shall be easily accessible for inspection and overhauling. Sufficient space for cleaning and replacing the tubes in the brine and RSW coolers and condensers shall be available.

102 If the refrigerating plant is located in a separate room outside the machinery space, this room shall be equipped with effective ventilation for cooling the refrigerating machinery. The mechanical ventilation shall have two main controls, one of which shall be operable from a place outside the room.

103 At least two sets of air breathing apparatuses with spare air bottles shall be available onboard. The breathing apparatuses may be the same as those required for other purposes, e.g. SOLAS, provided the ship is equipped with an air compressor for recharging the air bottles.

104 A complete operation manual for the refrigeration installation shall be available onboard.

105 Items 106 to 116 apply to refrigerants of Group 2.

106 Refrigerant gas masks and hermetically sealed filters shall be available in a glass door case located immediately outside each entrance to the space where the refrigerating machinery is located. Additionally at least two sets of suitable protective clothing including also gloves and boots shall be available onboard and located in the vicinity of the space for the refrigerating machinery. In case any one refrigerant circuit contains more than 25 kg refrigerant the two sets of protective clothing shall be gas tight suits with permanently attached boots and gloves and suitable for use in combination with the air breathing apparatuses.

107 Except as permitted in 115 and 116, the complete refrigerant circuit shall be located within a separate machinery room surrounded by steel decks and bulkheads and fitted with self-closing doors opening outwards and with a sill height of at least 300 mm but not less than sufficient to prevent overflow of refrigerant in case 80% of the total refrigerant quantity of the largest unit is released while the ship is within normal range of trim and with a list not exceeding 15°. Decks and bulkheads shall be without openings and pipe and cable penetrations etc. shall be sufficiently tight to prevent leaked refrigerant from entering other rooms and spaces. Special glands of approved type need, however, not be used.

The refrigerating machinery room shall be located as high as reasonable within the ship. The refrigerating machinery room is subject to approval with regard to its location and arrangement within the ship and with regard to accesses and emergency escapes. Except for small refrigerating machinery rooms, at least two access doors shall be provided.

108 Thin-plate ventilation ducts for other spaces shall not be lead through the refrigerating machinery room. Air coolers for air conditioning plants shall not be located within the refrigerating machinery room.

109 The ventilation system for the refrigerating machinery room

shall be separated from other ventilation systems, shall be of the exhaust type and to give minimum 30 air changes per hour. If the refrigerant is lighter than air the ventilation exhaust shall be from the top of the refrigerating machinery room.

110 The refrigerating machinery room is additionally to be equipped with effective mechanical catastrophe ventilation. For R717 the capacity shall be the larger of the values calculated by:

- 7,2 m³/h for each kg refrigerant up to 500 kg plus 3,0 m³/h for each kg refrigerant above 500 kg. In case the refrigerant is contained in completely separated refrigerant circuits, only the circuit with the largest quantity need be considered; or
- 300 m³/h for each m² deck area of the refrigerating machinery room. Special considerations will be made in case the deck is thermally insulated to reduce evaporation of leaked refrigerant or the wet area is minimised by the deck shape or construction.

For other refrigerants the required capacity shall be corrected according to the evaporating heat of the refrigerant at atmospheric pressure and the acceptable concentration in the ventilation exhaust air.

111 All ventilation outlets from the refrigerating machinery room shall be at safe locations with regard to:

- the hazards of possibly leaked refrigerant in the ventilation air
- intake of ventilation air into other ventilation systems on the ship
- recycling between the ventilation outlets and intakes for the refrigerating machinery room.

112 When the arrangement is such that a combined ventilation failure/refrigerant leakage within the refrigerating machinery room is considered hazardous for the continued operation and safety of the ship, the normal and the catastrophe ventilation shall be arranged such that a single failure cannot cause a complete ventilation failure for the refrigerating machinery room.

113 The normal and the catastrophe ventilation shall be arranged such that a single failure cannot cause a complete ventilation failure for the refrigerating machinery room.

114 If R717 is used as refrigerant the required separate refrigerating machinery room shall comply with the following:

- bilge wells and other recesses where leakage water will accumulate shall not be arranged
- the deck plating shall be arranged for easy cleaning and drying. Separate floor plating above the deck plating of the refrigerating machinery room shall not be fitted
- drain piping to bilge systems/bilge wells/bilges in other parts of the ship are not be arranged unless they are fitted with self closing valves
- all non-Ex protected electrical equipment within the refrigerating machinery room shall be automatically de-energised in case an R717 concentration above 10 000 PPM is detected. In case 112 or 113 apply the normal and catastrophe ventilation systems shall be arranged with Ex protected motors and non-sparking fans
- ex protected (emergency) lighting fixtures shall be fitted in the refrigerating machinery room
- access doors and emergency escapes shall be provided with external water screens and eye washes with constantly available water supply.

Separate refrigerating machinery rooms for R717 systems with less than 25 kg filling will be specially considered.

115 R717 may be used for direct expansion in cooling / freezing equipment located outside the refrigerating machinery room and within normally manned spaces such as production areas and cooled / frozen product cargo chambers on fishing vessels and fish factory ships. R717 piping shall not be located within the crew accommodation spaces, the navigating bridge and the main engine room or such that all accesses to the main engine room will be blocked in case of pipe rupture. Gas masks as referred to in 106 and emergency showers and eye washes as referred to in 114 are additionally required to be located outside all normal accesses to such spaces and cargo chambers. A water hose of adequate length with fog nozzle and constantly available water supply shall be located outside the main entrance to any such production area. For such areas:

- *their arrangement within the ship with tightness of bulkheads and decks*
- *self closing door arrangement*
- *accesses and emergency escapes*
- *ventilation arrangement (of under pressure type)*

are subject to special approval.

116 *On ships of less than 65 m of length (as defined in Pt.3 Ch.2 Sec.1 B101) R717 refrigerating systems with less than 25 kg filling may be located within the engine room or another suitable space not including accommodation spaces. All parts of such refrigerating systems shall be located together. A secondary refrigerant or a heat transfer fluid shall be used in the air coolers in provision stores, air conditioning systems etc. connected to such refrigerating systems. The area where the refrigerating system is installed shall be fitted with a hood with a negative ventilation system and with a water spray system. The outlet from the ventilation system shall be arranged in accordance with 111.*

B 200 Machinery in refrigerated chambers and cooling/freezing tunnels

201 For plants with direct expansion the total air cooler area/cooling grid area in each chamber is normally to be sufficient to ensure that the evaporating temperature is maximum 10°C colder than the chamber temperature as defined in A301 in any of the design operating conditions.

For indirect systems the mean value between the in- and outgoing brine temperatures shall be used in lieu of the evaporating temperature. When considering the capacity of the air coolers, the brine velocity is nowhere to exceed the values given as guidance in D204.

The air cooler overall heat transfer coefficient measured during the heat balance test shall be assumed constant when the verification calculations (based on the balance test results) of the cooling capacity at all design operating conditions are carried out.

202 In each chamber the air coolers shall be divided into at least two independent units with separate electrical supply for their air circulation fan(s), so that any one of them may be shut off without essentially influencing the others. For small spaces up to 300 m³ one unit may be considered.

203 In chambers fitted with cooling grids at least two independent circuits must be installed, so that any one of them may be closed without essentially influencing the others. For small spaces up to 200 m³ one unit may be considered.

204 In case of sub-zero air cooler temperature a defrosting system shall be installed.

205 Drip trays with water drainage shall be located under air coolers with forced air circulation and under cooling grids fitted vertically on bulkheads or ship sides. Drain pipes shall have an internal diameter of not less than 50 mm. For ships for frozen cargo the drip trays and drain pipes shall be fitted with heat tracing or alternative means for heating where relevant.

206 Fans and air coolers shall be easily accessible. Change of fan motors and fans shall be possible with the chambers fully loaded.

207 Where forced air circulation is installed, the fans shall be arranged with alarm for fan failure.

208 *All air cooler and freezing tunnel fans shall be fitted with effective protection grids or equivalent.*

209 *Fan emergency shut down buttons shall be fitted in all air cooler rooms or similarly.*

210 *Motors and other electrical equipment shall have suitable enclosures, see Pt.4 Ch.8 Sec.2 C.*

211 For chambers fitted with coolers with forced air circulation, the number of air circulations shall be at least:

- 90 pr. hour for bananas
- 60 pr. hour for fruit in general

- 30 pr. hour for frozen cargo.

Even distribution of the circulated air without «blind» zones shall be arranged.

Guidance note:

To obtain even distribution of the air, it is essential that the pressure losses in the distribution ducting/grating are small both longitudinally and athwartship compared to the losses at the inlet "nozzles" to the chamber. This will ensure that the various "nozzles" are supplied with the same air overpressure. Uncontrolled air supply to the chamber e.g. in connection with 'tween deck hatches or "leakages" between the grating and bulkheads/ ship-sides should be kept as low as possible.

For an air circulation system with the air supply through a homogeneously perforated grating, the highest mean air velocity through the perforations in any section of the grating should, when measured in an empty chamber, not exceed the lowest mean velocity in any other section by more than 75%.

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212 If the ship shall carry cargo in areas where the temperature in the chambers may fall below that specified for the cargo, it must be possible to heat the refrigerated chambers.

213 Chambers intended for bananas or fruit in general shall be equipped with an effective ventilation system giving at least 2 air renewals pr. hour. Each chamber shall have closeable separate feed and discharge ducts. The air intake shall be so placed that the possibility of foul air (from ventilation outlets from the same or other cargo chambers or from other ventilation outlets) coming into the chamber is reduced to a minimum. The air intake is normally to be located at least B/4 away from any ventilation outlet.

214 The required air circulation rates in 211 and air renewal rates in 213 shall be based upon the bale chamber volumes.

215 Other air circulation and air renewal rates than given in 211 and 213 may be accepted upon request and will then be specified in the Appendix to the classification certificate.

B 300 Refrigerant circuit

301 A direct expansion system shall be fitted with shut off valves to divide the system into a suitable number of sections. A section may include e.g. all chambers below the same hatch. The shut off valves shall be located outside the refrigerated chambers and shall be installed to ensure that the section may be completely separated for maintenance or repair etc. without affecting the operation of the other sections.

302 Shut off valves shall be fitted upstream and downstream of all filters, strainers and automatic expansion valves to facilitate cleaning, replacements and repairs.

303 *Where R717 is used as refrigerant for direct expansion within production areas and cargo chambers in accordance with 115, quick closing valves shall be fitted in the delivery lines (liquid and hot gas) within the refrigerating machinery room. The return lines are likewise within the refrigerating room to be fitted with a valve arrangement providing a quick closing function for prevention of flow towards the evaporators and a non-return function allowing flow towards the low pressure side within the refrigerating machinery room. All delivery line quick closing valves shall have common activation. All return line quick closing functions shall have common activation, however, separated from that of the delivery lines. Activation shall be possible from the refrigerating machinery room, the production area and from a suitably located emergency station outside these rooms.*

B 400 Cooling water arrangement. Condenser and brine cooler capacity

401 Cooling water shall be supplied from at least two sea connections to the water-cooled components of the refrigerating plant. For sea connections, see Pt.4 Ch.6 Sec.5.

402 A standby cooling-water pump, arranged for immediate use, shall be installed. The capacity of the standby pump shall

not be less than that of the largest of the other pumps. Automatic start of the standby pump need not be arranged.

403 The standby pump may also be used for other purposes on board, provided it has sufficient capacity to serve the refrigerating machinery at the same time.

404 With clean sea water side and water velocity as given by the normal sea water pump, however not exceeding the values given as guidance in D204, the condenser heat transfer capacity is normally to be sufficient to ensure that the condensing temperature is maximum 6°C warmer than the in-going sea water temperature in any of the design operating conditions.

When considering the overall refrigerating capacity, the condensing temperature shall be increased from the value found by the heat balance test by 2°C to take into account the fouling of the sea water side of the condenser.

405 The brine coolers shall be designed to ensure that the evaporating temperature normally is not more than 6°C colder than the mean between the in- and outgoing brine temperatures.

An increased design temperature difference across the brine coolers, however not exceeding 8°C, will be accepted provided the sum of the design temperature differences across the brine coolers and the air coolers (see 201) does not exceed 16°C.

B 500 Refrigerated seawater tanks (RSW)

501 Refrigerated seawater tanks for storage of catches of fish shall be kept at a temperature of -1°C at design ambient condition. The maximum allowable variation of the RSW temperature is 2°C. The arrangements of water inlets and outlets shall be such as to ensure even temperature distribution throughout the tank.

502 The RSW cooler shall be protected against freezing, e.g. by automatic shut-off of refrigerant suction line or automatic stop of the compressor(s) at loss of circulation.

503 A standby circulation pump shall be fitted. The standby pump may also serve other seawater services on board.

B 600 Compressors

601 Compressors shall comply with Pt.4 Ch.5 Sec.4. For ships with **RM** notation, materials for the compressor will be accepted with test report on material properties.

602 The compressors shall be equipped with all the accessories and instruments necessary for effective and dependable operation.

603 Oil coolers shall be installed, unless the service area of the cargo refrigerating plant is restricted to non-tropical waters.

604 *The low-pressure side of the compressor or the plant shall be so constructed that liquid refrigerant or oil cannot be sucked into the compressor in harmful quantities.*

605 *Safety valves or safety discs shall be located on the high-pressure side of the compressor ahead of the shutoff valve. The outlet may lead back to the suction side of the compressor.*

B 700 Vacuum operation

701 A refrigeration plant designed to operate with suction pressure below atmospheric shall be fitted with air separating equipment.

C. Electrical Installations

C 100 General

101 *All electrical installations shall comply with Pt.4 Ch.8.*

D. Accessories

D 100 Pipes and tubes

101 *Pipes and systems shall comply with Pt.4 Ch.6 Sec.6 and Pt.4 Ch.6 Sec.7 except where otherwise stated in this Chapter. Copper tubes and systems may be accepted with minimum wall thicknesses in accordance with Table D1. Welding of steel pipes shall be carried out according to an approved procedure. Grip type pipe couplings shall not be used.*

Table D1 Minimum nominal wall thickness for copper tubes for refrigerating systems (The table values correspond to ASTM B-280)

Dimension	External diameter (mm)	Wall thickness (mm)	
		annealed	halfhard
1/8	3.18	0.762	
3/16	4.75	0.762	
1/4	6.35	0.762	
5/16	7.92	0.813	
3/8	9.52	0.813	0.762
1/2	12.7	0.813	0.889
5/8	15.9	0.889	1.02
3/4	19.1	0.889	1.07
7/8	22.3	1.14	1.14
1 1/8	28.6		1.27
1 3/8	34.9		1.40
1 5/8	41.3		1.52
2 1/8	54.0		1.78
2 5/8	66.7		2.03

102 *Flexible hoses shall be of approved type. New types of flexible hoses, with couplings, shall be subjected to a prototype test. The bursting pressure shall be at least 4 times the design pressure for the system, unless Class I is applicable in accordance with Pt.4 Ch.6 Sec.1 B103.*

103 *The complete refrigerant circuit, including both low- and high pressure sides, shall be considered as pertaining to Class II piping systems.*

104 Piping which may be exposed to moisture, shall be protected against corrosion.

Guidance note:

For mild steel pipes hot dip galvanizing (minimum 70 microns) or shot blasting to SA 2.5 followed by a minimum 2 coat paint system with a minimum total dry film thickness of 250 microns are considered a suitable protections.

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105 *Soldered connections shall be able to withstand a temperature of at least 425°C if refrigerants of Group 2 are used.*

106 *When tin soldering, the solder shall be of a type which does not decompose.*

107 Cold refrigerant liquid and gas pipes and cold brine pipes shall be insulated where necessary to prevent the harmful or damaging effect on equipment, cargo chambers or cargo from condensation or frosting (with subsequent defrosting).

108 Any insulation of refrigerant and brine pipes shall be efficiently protected against the diffusion of moisture.

Guidance note:

Insulation and water vapour barriers should preferably be led continuously through the fastening arrangements.

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D 200 Pressure vessels and heat exchangers

201 *Pressure vessels shall be constructed in accordance with Pt.4 Ch.7. Pressure vessels for refrigerant of Group 2 shall comply with the requirements for Class I pressure vessels. Requirements for thermal stress relief of pressure vessels with fluids liable to cause*

stress corrosion cracking (e.g. ammonia, R717) are given in Pt.4 Ch.7 Sec.8 C101.

202 Pressure vessels in closed refrigerating circuits will normally be accepted without inspection openings.

203 Receivers with shut off valves which together can take the complete filling of refrigerant shall be installed.

204 Condenser cooling water tubes shall be made of materials with high resistance to corrosion and erosion.

Guidance note:

The water velocity should not exceed:

- 2.5 m/s for aluminium brass pipes
- 2.5 m/s for 90/10 copper/nickel pipes
- 1.5 m/s for steel pipes.

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For sea water cooled R717 condensers the condenser tubes and tubeplates shall be made of materials resistant to both sea water and ammonia corrosion. Use of coating or lining systems will not be accepted in lieu of corrosion resistant materials.

205 Heat exchangers including plate heat exchangers for the refrigerant or for compressor lubricating oil shall be certified by the Society except as stated in 206 and 207.

206 Direct expansion air coolers with an air cooling surface, including extended surface, exceeding 50 m² shall be certified by the Society.

207 Direct expansion plate freezers need not be certified by the Society provided use of acceptable materials and compliance with 102 can be documented.

D 300 Brine piping system and vessels

301 Special consideration shall be given to corrosion resistance of materials.

Guidance note:

A corrosion-reducing agent consisting of 2.0 kg sodium dichromate + 0.54 kg caustic soda for each m³ of the solution should be added to calcium chloride. The pH value should be about 8. It is advised that a closed brine system be installed.

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302 If internally galvanized vessels or pipes are used with a closed system, and if the brine attacks zinc, the vessels shall be vented to a safe place in open air. At the outlet, the pipes shall be equipped with safety equipment against back flaming.

303 With an open system, the rooms where internally galvanized brine tanks are located shall be effectively ventilated, and brine, which generates gases with flash point lower than 30°C, shall not be used.

304 The thickness of the brine pipes from the bottom of the threads shall not be less than 2.5 mm.

D 400 Safety valves and discharge system

401 The refrigerant circuit(s) shall be protected against excessive pressure by safety relief valves, rupture discs or equivalent arrangements.

402 If a shut-off valve is located between the pressure vessel and the safety valve, it shall be sealed in open position, and shall be closed only during repairs. A signboard stating this requirement shall be fitted.

403 Vessels with shut-off valves which contain liquid refrigerant shall be protected by a safety valve. For refrigerants of Group 1, a safety disc which is corrosion-resistant, may be substituted for the safety valve.

404 The safety valve and safety disc shall be located above the surface of the liquid. They shall open at a pressure not less than the design pressure and shall be fully effective at a pressure which is maximum 10% higher.

405 The safety valve and safety disc shall have a minimum capacity determined from the following formula:

$$G = \frac{FS^{0.8}}{r} (\text{kg/s})$$

- F = 58000 if the vessel is placed in a room which contains combustible materials
- = 12000 otherwise
- S = the total surface of the vessel(s) protected, in m²
- r = the heat of evaporation of the refrigerant in J/kg at the relieving condition.

The minimum flow area required may for R22, R134a and R717 be decided from the following formula:

$$A = \frac{GC}{10K(p+1)} \sqrt{\frac{T}{M}} (\text{cm}^2)$$

- C = 141 for R22
- = 142 for R134a
- = 136.5 for R717
- K = the contraction coefficient of the safety valve or the safety disc
- p = the design pressure (gauge) as given in A500
- T = absolute temperature in °K at the relieving condition
- M = the molecular weight of the refrigerant.

406 A pipe with outlet opening at a position which is not considered dangerous for the ship or the surroundings of the ship, shall be led from the safety valve or the safety disc.

If led to the atmosphere the outlet opening shall be protected against rain and snow and shall be fitted with a protection net made of corrosion resistant material to prevent ingress of foreign objects.

When R717 is used as refrigerant the outlet shall be at a safe location as high as possible on the ship e.g. top of funnel or top of mast. The outlet shall be directed upwards.

407 The discharge piping system from the relief devices shall have sufficient capacity to ensure critical flow through the relief devices. In lieu of correct calculations, the following simplified formulae may be used for R22, R134a and R717:

$$d_{R22} = 36.4 \sqrt[5]{(\Sigma G)^2}$$

$$d_{R134a} = 35.1 \sqrt[5]{(\Sigma G)^2}$$

$$d_{(R717)} = 51.2 \sqrt[5]{(\Sigma G)^2}$$

d = internal diameter in mm of the discharge pipe.

When using the above formulae for calculating the diameter of a particular piece of pipe, the sum of the mass flows in kg/s of all relief devices connected to this piece of pipe shall be used.

D 500 Oil separators, filters and driers

501 Oil separators shall be located in the pressure pipe ahead of the condenser, or ahead of the intercooler, if any.

The plant shall be arranged and equipped to ensure that any lubricating oil bypassing the oil separator is satisfactorily returned to the oil system. Whenever relevant, the lub oil system shall be fitted with heating arrangements to boil out any accumulating refrigerant.

502 Filters or strainers shall be located in the liquid lines upstream of the expansion valves and in the suction lines upstream of the compressors.

503 Any driers necessitated by the refrigerant used shall be

located in the liquid lines downstream of the condensers.

504 The drying agent shall be replaceable during operation.

D 600 Temperature, pressure and level indication

601 The temperatures of the refrigerant on the suction and discharge sides of compressors, of the cooling water upstream and downstream of the condensers, of the brine and the refrigerated sea water (RSW) feed and return as well as of the refrigerant from all coolers and freezers with direct expansion, shall be indicated.

602 The pressure of the refrigerant in the suction lines, intermediate stages and delivery lines of the compressors, in the refrigerant circulation pumps' delivery lines, in the return lines from all direct expansion air coolers and freezers and on the brine pumps' pressure side shall be indicated.

603 Level indication shall be provided on liquid receivers.

It shall be possible to close the indicators so that the loss of large quantities of the refrigerant may be prevented in event of breakage.

604 *In case of liquid-level indicators with glass tubes, a valve which closes automatically for the refrigerant or oil in event of breakage, shall be fitted.*

E. Instrumentation and Automation

E 100 General

101 The rules in Pt.4 Ch.9 regarding documentation to be submitted for approval, system design, component design and installation shall be complied with.

E 200 Automatic control

201 Where automatically operated expansion valves are used, manually operated bypass valves shall be provided. Alternatively, duplicated automatic valves can be accepted.

202 The automatic control systems shall keep the cooling capacities within acceptable limits at all design operating conditions.

E 300 Monitoring

301 The monitoring system shall cover machinery and equipment necessary for the safety of the cargo cooling machinery and to ensure a correct carriage temperature for the cargo. The parameters to be monitored will depend upon output and type of machinery as well as arrangement of the plant. Other combinations of measuring points than those listed below may be accepted when an equivalent degree of safety is achieved.

302 *A refrigerant leakage detection system with alarm covering all spaces with refrigerating machinery, the outlet piping from safety relief devices and, in case of direct expansion, all refrigerated chambers shall be installed.*

For plants using group 1 refrigerants monitoring for oxygen deficiency is an acceptable alternative to refrigerant gas detection. If not covered by class notations in this chapter, these plants need not fit gas detection in outlet piping from safety relief valves.

In case a sampling system with sequential analyzing is used, each

sampling point shall be analyzed at intervals not exceeding 1 hour. Sampling lines shall be monitored with regard to flow failure.

The sensors / sampling suction points shall be located with due regard to the relative density of the refrigerant in gas form as well as to the ventilation flow.

The acoustic and optical alarm signals shall be given at such locations that crew members attending to an alarm will not be led to entering a space possibly filled with refrigerant.

For provision and air condition refrigeration plants using Group 1 refrigerants located in the Engine Room, leakage detection systems need not be fitted if the ventilation arrangement is considered sufficient to eliminate the risk of suffocation.

When R717 is used leakage detectors covering compartments with refrigerating machinery (including process vessels) shall give audible alarm within the compartment.

When R717 is used refrigerant leakage in the refrigerating machinery room shall be detected at 3 different consecutive levels with a set points not higher than:

150 PPM *Initial detection of leakage*

5 000 PPM *Access dangerous. Automatic shutdown of refrigerant circulation pumps, closing of quick closing valves in delivery lines, etc.*

10 000 PPM *De-energising of non-Ex protected electrical equipment.*

When R717 systems, in accordance with B115 and B116, are accepted in other spaces than a separate refrigerating machinery room these spaces shall be covered by a refrigerant leakage detection system with alarm levels not higher than 350 PPM and 1 500 PPM as given above.

Leakage detection of R717 at the 2 higher levels shall be of continuous type.

303 Alarm is required for the following fault conditions:

- fresh air fans, failure
- circulating fans, failure
- brine/RSW temperature, high and low
- low level in the brine header tank
- sea cooling water temperature outlet condensers, high.

304 All chambers shall be fitted with equipment able to give alarm in case the chamber temperature as defined in A301 deviates from from high/low set values selected by the vessel's officers.

305 Automatic stop of compressor with alarm is required for the following fault conditions:

- suction pressure, low
- discharge pressure, high
- discharge temperature, high
- lubrication oil pressure, low
- low superheat temperature in the suction line or low compressor discharge temperature
- liquid return from evaporators, (e.g. high level in suction line liquid separator).

306 For vessels without a continuous watch attending to the refrigeration plant the above listed alarm and stop functions are, except as given in 302, to be connected to the engine room alarm system.

SECTION 4

REFRIGERATED CHAMBERS. CONSTRUCTION, INSULATION AND INSTRUMENTATION

A. Arrangement and Design

A 100 General

101 Gastight bulkheads of steel or equivalent material shall be erected between the refrigerated chambers and the other rooms of the ship, as well as between the individual chambers, if these are intended to contain cargo which interacts with gas produced by the cargo in an adjacent chamber.

Each separately insulated chamber or group of chambers shall be gastight.

Guidance note:

With all hatches, ports, doors, ventilation outlets and other openings closed with their normal closing appliances, an air supply through the ventilation inlet giving an internal overpressure in the chamber(s) of 40 mm water column should normally not cause an air flow in excess of 0.25 air changes per hour.

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102 Where oil tanks are located adjacent to vertical boundaries of refrigerated chambers, no manholes in these boundaries are permitted.

103 Bilge wells shall be separated from the insulated cargo chambers by a gas tight construction.

104 All hatches, cargo ports, doors, etc., which lead to the refrigerated chambers, as well as pipes and ducts leading through the refrigerated chambers, shall be satisfactorily gastight.

105 Tank top insulation in way of manholes shall be provided with a liquid tight coaming to prevent seepage into the insulation.

106 *Uninsulated steam supply and return pipes shall not be located within double bottom fuel oil tanks below insulated cargo chambers. Such pipes are normally to be insulated and located within a pipe duct or to be led above deck.*

107 *All chambers and air cooler rooms shall have access doors, hatches and ladders arranged for easy access and escape. Due account shall be taken to the possibilities to remove injured personnel and the use of stretchers as well as to obstructions by the cargo when the chambers are loaded.*

Cooled/frozen cargo chambers with direct expansion air coolers and with vertical access are if they are normally manned, such as on fishing vessels and on fish factory ships, to be fitted with permanent hoisting arrangements for removal of injured/unconscious crew members.

108 *Access doors and -hatches shall either be operable from both sides or be fitted with catches to prevent inadvertent closing.*

109 *All chambers and air cooler rooms are each to be fitted with at least one conveniently located alarm call button.*

A 200 RSW tanks

201 Requirement for the lining and insulation of RSW tanks are given in Ch.6 Sec.1 E300.

B. Insulation Construction

B 100 General

101 Steel, which shall be covered with insulation, shall be cleaned thoroughly and shall be painted with a rust-proofing coating.

Guidance note:

Shot blasting to SA 2.5 followed by a minimum 2 coat paint sys-

tem with a minimum total dry film thickness of 250 microns is considered a suitable protection.

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102 Bolts, nails and steel fittings shall be galvanized.

103 Concealed woodwork shall be pressure/vacuum impregnated with a recognized odourless preservative. All wooden materials shall be well dried before use.

104 Metallic fittings or other items passing through the insulation and which may form a heat-conducting bridge, shall be avoided as far as practicable.

105 On the 'tween decks and bulkheads which are not fully insulated, strip insulation shall be used.

Guidance note:

If the insulation is made from slabs, several layers laid with staggered ends, should preferably be used. The seams between the slabs shall be filled with a recognized, odourless material. The thickness of the insulation should preferably be adjusted so that the heat transmission per unit area is of the same magnitude for all surfaces.

Heat gain through the deck plates, bulkhead plates and stiffeners should preferably not exceed 20 W per metre of edge length.

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106 *Insulation adjacent to engine and boiler room shall be made of non-combustible material.*

107 The lining and insulation shall be arranged for regular inspection of the insulation and hull members behind it.

B 200 Insulation on sides, bulkheads and below deck

201 The insulation shall be securely fastened or thoroughly packed, so that settling caused by vibrations and deformations is avoided.

Guidance note:

At frames and deck beams, any form of heat-conducting bridge should preferably be avoided.

Where plane bulkheads are insulated, attempts should be made to reduce or eliminate through connections by using insulation materials with sufficient strength to resist load from the cargo.

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B 300 Insulation on tank top and 'tween decks

Guidance note:

The insulation should preferably be of a material with sufficient strength to withstand the weight from the cargo, so that through connections are avoided.

The insulation, especially on the tank top, should preferably be of a material with particularly high resistance to penetration of moisture.

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B 400 Insulated hatches and doors

Guidance note:

Attempts should be made to reduce the weight of the hatches and the doors to the extent possible, using light materials and constructions which have little tendency to warp. Insulation materials with great strength, little weight and a low coefficient of thermal conductivity should preferably be chosen. Attempts should be made to avoid heat-conducting bridges.

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401 Hatches and doors with frames, packings, hinges, locking devices etc. shall be of reasonably gas tight construction.

402 On ships designed for carriage of fruit in general or bananas, with class notation **Reefer** hatch covers and doors between insulated chambers must be provided with double seal packings. Hatch covers and doors exposed to weather, must in addition to double seal packing have packing for weathertightness with compression bar of corrosion resistant material. For smaller covers or doors exposed to weather, two packings may be accepted.

403 Fittings, hinges and handles shall be corrosion resistant.

B 500 Protection of cooling grids and refrigerant pipes. Pipe and other penetrations

501 Cooling grids located on sides and bulkheads shall be protected with dunnage ribs.

Guidance note:

Wooden ribs should preferably be about 50 x 150 mm with a spacing of approximately 300 mm.

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502 The refrigerant pipes shall be securely fastened and protected.

503 *Where the refrigerant pipes, electrical cables etc. pass through gastight bulkheads or decks, the construction shall be gas-tight and fireproof.*

Refrigerant pipes shall not be in metallic contact with the steel parts of the ship. Stuffing boxes shall be able to take thermal movements of the pipes

B 600 Lining and protection of insulation

601 The lining in refrigerated chambers shall be constructed and fitted to prevent circulating air from entering the insulation, causing forced convection in the insulation. When using insulation materials with low resistance to convection, special care shall be taken. The lining on decks, sides, bulkheads and below decks shall be of a material and of a workmanship which will not be damaged or allow water to penetrate into the insulation during hosing down of the chambers.

602 The lining of all surfaces shall have sufficient strength to withstand load from the cargo.

603 In addition to sufficient mechanical strength, the lining shall be:

- impervious to water, and it shall not crack at the service temperatures and stresses
- satisfactorily resistant to corrosion by oil, organic matter or other material with which it may come into contact
- odourless. Bitumen solution shall not be used unless all the solution agent is evaporated before the room is used.

604 Under the hatches and approximately 0.6 m outside their edges, the insulation on the tank top and shaft tunnel shall be protected with an extra covering of hardwood about 50 mm thick, or another efficient covering, for instance fixed or removable gratings, which is not damaged to any appreciable extent by impacts during loading and unloading.

605 Where the insulation shall support fork lift trucks, the strength of the lining and its support shall be demonstrated. A sample of the insulation construction, approximately 4 x 4 m, shall be prepared and tested by a fully loaded fork lift truck being driven and manoeuvred over the sample.

C. Protection against Moisture

C 100 Design and workmanship

Guidance note:

When insulating, care should be taken that the air in the room has a dew point lower than the temperature of the surfaces being insulated.

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101 Air pipes, hatchways, etc. shall be constructed and located such that the chambers are not fed with moisture from spray and shipped water.

102 Before the insulation is laid, the tightness of bulkheads shall be verified by hose or pressure testing.

Guidance note:

Insulation should preferably be laid on the side of the bulkhead which is normally cooled.

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103 Provisions shall be made for the efficient drainage of the chambers, especially if the ship shall carry cargo giving off water.

104 The inside lining shall be constructed of a material with high resistance to moisture and moisture diffusion. All the joints, inclusive of the joint between the deck and sides, shall be as resistant as possible to moisture diffusion.

Guidance note:

Measures against condensation on the warm side of the bulkheads and decks should preferably be taken by using heating cables or similar devices.

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D. Air Circulation System and Drainage, Air, Sounding and Water Pipes

D 100 Air circulation system

101 The chambers shall be arranged for adequate air circulation around/through the cargo taking into account the types of cargoes carried. The arrangements shall be satisfactory also when the chambers are only partially loaded. The air circulation arrangements may be based on permanent installations, on portable equipment and/or on operational procedures for stowage and packing of the cargo. Local high-velocity air streams which may damage the cargo shall be avoided. A permanently installed forced air circulation system shall be arranged with well-rounded corners and other detail designs to reduce the air flow resistance.

102 In ships with class notation **Reefer** designed for carriage of fruit in general or bananas, the chambers shall be fitted with an arrangement for distributing the cooling air at the bottom, e.g. by means of ducts and grating.

103 In ships not fitted with an air distribution grating the cargo shall be stowed on pallets or otherwise be lifted clear of the deck or bottom insulation to ensure air circulation below the cargo.

104 Unless arrangements are made for air circulation through the stowed cargo the bulkheads and ship sides shall be fitted with battens.

105 In ships with class notation **Reefer** provision shall be made for adequate air circulation in the chambers inside hatch coamings foreseen for stowage of cargo, for instance by return air channels from top of hatch coamings.

106 The walls of air ducts and air cooler rooms shall have sufficient strength to resist pressure from the cargo, and shall be as airtight as possible, especially against insulated surfaces.

D 200 Drainage

201 Drain pipes from the chambers and from the cooler drip trays shall have liquid-sealed traps or equivalent means to prevent air communication between chambers and from the bilge wells to the chambers.

202 Drain pipes from chambers and from cooler drip trays shall have check valves or equivalent means to prevent water communication between chambers.

203 Liquid-sealed traps are normally to be placed on the warm side of the insulation and shall have at least the following pressure heads: 100 mm when connected to air ducts, 50 mm otherwise.

204 If liquid-sealed traps are located inside the refrigerated spaces, they shall be easily accessible for checking and refill with brine.

205 Drain pipes from other rooms shall not lead down to bilge wells for refrigerated chambers.

Guidance note:

Overboard drain pipes should meet the requirements given in Pt.3 Ch.3 Sec.6.

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D 300 Air, sounding and water pipes

301 Air and sounding pipes through the cold chambers shall be effectively insulated.

302 Pipes shall be well insulated from cold decks, but shall have the greatest possible contact with relatively warm decks, bulkheads or ship's sides.

303 The inside diameter of sounding pipes shall not be less than 65 mm, if the temperature of the chamber is below 0°C. Sounding pipes for oil tanks shall not end in refrigerated chambers or rooms for fans or air coolers.

Guidance note:

Water pipes and air and sounding pipes through freezing chambers should preferably be avoided.

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304 *If air pipes for tanks or sea chests and water pipes are passing through freezing chambers or its insulation, they shall be arranged to prevent freezing.*

305 *Air, sounding and water pipes penetrating the tank top shall have substantial wall thickness in way of the insulation on the tank top.*

306 *Bilge wells for refrigerated chambers will be accepted with a level alarm in lieu of a sounding pipe.*

In ships with class notation **Reefer** designed for carriage of fruit in general or bananas, 2 independent level alarms are required in each bilge well without sounding pipe.

E. Equipment for Temperature Measurements. Gas Indication Equipment

E 100 Equipment for temperature measurements

101 The rules in Pt.4 Ch.9 regarding documentation to be submitted for approval, system design, component design, and installation shall be complied with.

102 In chambers with forced air circulation through coolers, at least one thermometer is required in the circulated air enter-

ing each air cooler, and at least one in the circulated air leaving each air cooler. Additional thermometers may be required dependent upon the arrangement of the air circulation system.

103 In chambers without forced circulation through air coolers the number of thermometers shall not be less than:

Up to approximately 200 m ³ net volume	3 thermometers
Up to approximately 400 m ³ net volume	4 thermometers
Up to approximately 600 m ³ net volume	5 thermometers

and then one thermometer in addition for each approximately 300 m³ net volume. On ships intended exclusively for frozen cargo a smaller number of thermometers may be accepted based on the arrangement of the air coolers.

104 More thermometers may be required depending upon the geometrical configuration of the chambers.

105 The thermometers shall be suitably arranged in the refrigerated chambers and in such a way that temperature reading is possible without entering the chamber.

106 For RSW installations thermometers are required in pipes entering and leaving RSW tanks.

107 When only electronic thermometers are fitted, at least two mutually independent systems with separate power supply shall be installed. The sensing elements in each chamber shall be divided between the two systems in an appropriate manner. One of the indicating instruments may be a data logger. The data logger shall comply with the requirements in 108.

108 The thermometers shall cover the temperature range from 10°C above the highest expected cargo temperature at loading to 5°C below the lowest design operating chamber temperature.

109 The accuracy of the thermometers at the design temperatures shall be ±0.5°C for frozen cargo and ±0.25°C for fruit in general and bananas.

In the above limits are included possible errors from resistance variations in cables and instrument reading errors. The combined errors of instrument reading and hysteresis shall be less than 0.1°C.

The scale deflection of analog instruments is for bananas and fruit in general not to be less than approximately 5 mm/°C and for frozen cargo not to be less than 2.5 mm/°C.

The temperature reading shall be possible within 0.1°C on both analog instruments and digital displays.

110 The sensing elements shall be well protected against damage from mechanical abuse and moisture. They shall be permanently connected to their instruments, i.e. no plug-in connections are allowed.

111 Instruments for remote thermometers shall comply with the requirements of Pt.4 Ch.9. The installation is in general to comply with the requirements of Pt.4 Ch.8.

E 200 CO₂ indication equipment

201 All chambers designed for carriage of fruit in general or bananas shall be fitted with permanently installed equipment for indication of CO₂ content.

E 300 Oxygene indication equipment

301 *Cargo chambers shall be fitted with arrangements to facilitate measurement of the O₂ content without entering the chamber. Any portable O₂ analyzer necessary for this purpose shall be kept onboard.*

SECTION 5 CONTROLLED ATMOSPHERE

A. General

A 100 Application

101 The requirements in this Section apply to ships built and equipped for operation with a controlled atmosphere (CA) with low oxygen content in the refrigerated cargo chambers for the purpose of slowing down the ripening process and quality reduction of bananas and fruit in general.

102 These requirements are supplementary to those applicable for class notations **Reefer** or **RM**.

A 200 Class notations

201 Ships satisfying the requirements of this Section may be given one of the following class notations:

- CA** which applies to ships fully and permanently equipped for operation with controlled atmosphere.
- CA(port.)** which applies to ships for which the use of a portable nitrogen generating and possibly instrumentation unit has been foreseen for operation with controlled atmosphere.

202 The following requirements apply in case of class notation **CA(port.)**:

- the portable unit may be common to several ships
- the complete installation including the portable unit is in principle to comply with all relevant items of this Section
- the location of the portable unit onboard the ship is subject to approval
- the scantlings of the portable unit shall be in accordance with the requirements for a deckhouse in the same location. If the unit is built as a container with ISO type corner fittings, relevant parts of the DNV Rules for Freight Containers will be applied. The container fittings for the portable unit shall meet the requirements of Ch.2 Sec.6
- the portable unit with its equipment shall be subject to approval by the Society and shall be covered by a certification procedure accepting its use in connection with one or more identified ships
- each time a portable unit is placed onboard a ship, a preloading functional test in accordance with an approved procedure is required. Such tests need not be carried out in the presence of a surveyor
- the portable unit shall be covered by annual and complete periodical surveys. Such surveys shall be carried out while the unit is installed onboard one of the applicable ships to facilitate realistic testing.

A 300 Basic assumptions

301 It has been assumed that in no cases, except for the rescue of personnel in danger, will spaces with a low O₂ content be entered.

302 It has been assumed that appropriate onboard procedures will be established to ensure that all CA compartments are free from personnel and adequately locked before injection of low O₂ gas is commenced.

303 Unless a thorough tightness test has been carried out after the closing of the 'tween deck hatches, it has been assumed that a cargo chamber will not be put under controlled atmosphere until loading of all chambers under the same main weather deck hatch is completed. Correspondingly it has been assumed that unloading of a chamber will not be commenced until all chambers under the same main hatch have been com-

pletely ventilated to a normal atmosphere unless the above prescribed tightness test was carried out prior to the loading of the upper chambers.

304 It has been assumed that when one or more chambers are under controlled atmosphere then the gas monitoring and alarm system of any adjacent chamber with a normal atmosphere will be kept in operation with relevant alarm set point.

305 It has been assumed that the controlled atmosphere chambers are maintained at a pressure as close as possible to the atmospheric pressure.

306 It has been assumed that certified test gases will be available onboard and used for regular calibration of all gas analyzing equipment.

A 400 Documentation

401 In addition to the documentation required for the class notations **Reefer** or **RM** the following documentation shall be submitted:

For approval:

- an arrangement plan including:
 - location of CA chambers and gas tight subdivisions
 - design overpressure
 - location of equipment for CA
 - arrangement and use of spaces adjacent to CA chambers
- piping diagram for CA supply and vent gas
- plan showing pipes led through CA chambers
- drawings of cleating, hinging and sealing arrangement for gastight weather- and 'tween deck main hatches, access hatches and loading- and access doors
- gas tight glands for pipe and cable penetrations
- ventilation arrangement including:
 - gasfreeing of CA chambers
 - ventilation of spaces adjacent to CA chambers or containing CA equipment
- plan showing the location of outlets from relief valves, ventilation systems etc. of gases which may have abnormal low or high oxygen content
- capacity calculations for CA chamber pressure relief valves
- diagram of N₂ release prealarm system
- plan of water seal arrangement for drains from CA chambers
- plans of nitrogen generating equipment
- plans of carbon dioxide scrubber equipment if installed
- electrical drawings, see Pt.4 Ch.8 Sec.1 B
- instruction manual
- documentation relating to a possible portable equipment unit including its installation onboard.

For information:

- description of the CA installation.

402 Information required above may be included in drawings and documentation submitted for class notations **Reefer** or **RM**.

403 For requirements for documentation of instrumentation and automation, including computer based control and monitoring, see Sec.1.

B. Arrangement and System

B 100 General

101 For assignment of the class notations **CA** or **CA (port.)** at least 50% of the ship's total refrigerated cargo chamber volume shall meet the requirements for operation with controlled atmosphere.

102 Chambers intended for CA shall be gastight. Alternatively a group of two or more chambers may be arranged as a common gastight unit intended to be operated with the same atmosphere.

103 A design overpressure with respect to gas tightness shall be defined for the chambers. The design overpressure shall be between 0.002 bar (20 mm water column) and 0.01 bar (100 mm water column).

104 During a tightness test after completed construction and outfitting all chambers or gastight groups of chambers are individually to be pressurized to their design overpressure. With all openings closed with the ordinary closing devices and without air supply the pressure loss during 15 minutes shall not exceed 30% of the design overpressure.

105 Each chamber or gastight group of chambers shall be fitted with at least one pressure relief valve. The pressure set point and the pressure relieving capacity shall be such that with the maximum capacity of the gas generating unit being delivered to any one chamber, the pressure in that chamber shall not exceed its design overpressure.

106 The liquid sealed traps on drains from chambers, air cooler drip trays etc. shall have a liquid head at least 50 mm greater than the chamber design overpressure. When the drains are connected to the pressure side of the chamber air circulation fans, the excess liquid head of the traps shall be at least 100 mm or otherwise as necessary due to the maximum pressure head of the circulation fans.

107 Bilge wells for CA chambers shall be fitted with air pipes to a safe location on open deck. Spaces and chambers not intended for CA shall not have bilge wells common with CA chambers.

108 N₂ generating equipment shall not be located within the accommodation. Such equipment is preferably to be located within a well ventilated part of the engine room. In case N₂ generating equipment is located within a separate space, this space shall be equipped with a permanent ventilation system of the extraction type giving at least 6 air changes per hour.

109 An hazardous area arrangement plan including also general information about the hazards caused by a low oxygen level shall be posted within the crews living quarters. The information shall be given in a language/languages understood by the crew.

Guidance note:

When in this Section a reference is made to "spaces adjacent to CA chambers" this does not include other cargo chambers whether or not used or arranged for CA. Requirements for such cargo chambers are given directly in the text.

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B 200 Access

201 All access doors and -hatches to CA chambers and air cooler rooms shall be fitted with locks/pad lock arrangements. Key for emergency opening shall be available in a nearby glass locker. Signboards warning against the possibility of a low oxygen atmosphere shall be fitted.

B 300 Piping systems

301 Pipes for other media are preferably not to be led through chambers with controlled atmosphere.

302 All pipes (e.g. air pipes, sounding pipes, drain pipes from overlaying chambers, ventilation pipes for underlaying chambers, etc.) led through chambers with controlled atmosphere and which in case of a leakage may cause unintended low oxygen atmosphere in other spaces, shall be of a material and of a design that will ensure permanent tightness. Such pipes shall, if covered by the chamber insulation and if made of black steel, have wall thicknesses in accordance with the right hand column of Table A2 of Pt.4 Ch.6 Sec.6 A200. Gas sampling pipes will be considered specially.

Guidance note:

When acceptable with regard to watertight and fire protecting subdivision it is advised to utilize plastic pipes as far as possible. Spiro type ventilation ducts will be accepted only within the chamber where they have their open ends.

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303 N₂ supply pipes shall not pass through the accommodation and are otherwise to be located with due regard to the hazards of a possible pipe leakage.

304 In case the system is arranged for external supply of N₂, an automatic shut off valve shall be fitted at the connection for the external supply. This valve shall close in case of excessive pressure in any of the CA chambers. Alternative means to protect the chambers against an excessive supply of N₂ will be specially considered.

305 The N₂ inlet valve arrangement to each chamber or gastight group of chambers shall include a set of valves in an interlocked fail to safe double-block-and-bleed arrangement.

To facilitate operation without an overpressure in the CA chambers, it is recommended that each chamber or gastight group of chambers is fitted with a vent valve connected to the inlet valve arrangement to ensure that supply of N₂ is normally carried out with the chamber vent valve in open position. An override arrangement with automatic reset to the normal condition may be arranged.

Arrangements for serial supply of N₂ between chambers will be specially considered.

When a portable gas generating unit with separate hose connections to each CA chamber or gastight group of chambers is used, the double-block-and-bleed arrangement may be omitted provided operational procedures are established to ensure that the hoses are not connected until the chamber is ready to be put under controlled atmosphere and to ensure that hoses are not connected for other CA chambers. Similarly the procedures shall ensure that hoses are disconnected prior to unloading the chamber.

306 All outlets from CA chambers and from pressure relief valves on the N₂ distribution pipes shall be located at least 2 m above the main deck or any gangway, platform, trunk, etc., if situated within 4 m of the gangway, platform, trunk, etc. Due regard shall be given to the distance between such outlets and ventilation intakes or openings to spaces.

307 Outlets used during ventilation of the CA chambers shall be directed vertically upwards. See C202.

308 Pipes connected to CA chambers are normally not to have open ends or connection possibilities within enclosed spaces. Equipment connected to such pipes may normally be located within enclosed spaces only if the equipment is substantially gastight.

B 400 Ventilation of adjacent spaces

401 All normally accessible spaces adjacent to cargo chambers with controlled atmosphere or where a pipe leakage, equipment leakage etc. may cause an oxygen deficient atmosphere, shall have a permanent ventilation system operable from outside the space and giving at least 6 air changes pr. hour.

Guidance note:

Spaces without permanent electrical lighting will normally not be required to have a fixed ventilation system.

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402 All other spaces or tanks adjacent to cargo chambers with controlled atmosphere shall be arranged for efficient ventilation, e.g. by use of portable ventilators. Suitable air inlet and exhaust openings shall be arranged. Permanent ducting within the space or tank may be required if considered necessary. For ballast tanks, ballasting with subsequent deballasting will be considered as efficient ventilation.

403 At least two portable ventilators suitable for use on the above mentioned inlet or exhaust openings and with a nominal capacity equivalent to at least 2 air changes pr. hour in the largest of the relevant spaces/tanks shall be available onboard.

B 500 N₂ release prealarm

501 Means shall be provided for automatically giving audible warning of injection of N₂ into any chamber or gastight group of chambers. The alarm shall be given continuously for at least 60 seconds before injection can take place. The operating medium for the alarm shall be taken from the supply of operating medium for the double-block-and-bleed inlet valve arrangement in such a way that the inlet valve cannot be opened unless the alarm signal has been given. The alarm may be interlocked with the O₂ analyzer in such a way that alarm is not given when the O₂ content in the chamber is below 14% by volume.

C. Operational Performance

C 100 Atmosphere quality

101 Equipment shall be installed making it possible to maintain in any chamber or gastight group of chambers any O₂ level between 10.0% and 2.0% by volume with an accuracy of $\pm 0.2\%$ by volume or better.

102 The ship shall be fitted with equipment making it possible to reduce excessive concentrations of CO₂ in any chamber or gastight group of chambers. Between 0.2% and 10.0% CO₂ by volume the equipment shall make it possible to maintain any desired CO₂ concentration with an accuracy of $\pm 0.2\%$ by volume or better.

C 200 Required capacities

201 The N₂ generating equipment at normal operating temperature and at 4.0% O₂ shall have a capacity in Nm³/h not less than 0.05 times the total bale volume of all CA chambers. At 2.0% O₂ the capacity shall be at least 50% of the above. The capacities stated shall be available at the inlet openings to the chambers at a backpressure equal to the pressure setting of the pressure relief valves.

202 Each chamber or gastight group of chambers shall be fitted with a ventilation system able to give at least 2 air changes pr. hour based on the bale volumes. See Sec.3 B213.

D. Nitrogen Generator. Carbon Dioxide Scrubbers

D 100 Nitrogen generator

101 The piping system, the pressure vessels including separation or adsorption units and the compressors shall meet the requirements of Pt.4.

102 Active components including compressors shall be arranged with redundancy. Two compressors with approximately 50% of the required capacity will be accepted. The main and additional units need not be exclusive for the nitrogen generator provided they may always be made available for this purpose. Passive components such as gas separators or adsorption units need not be duplicated.

103 A suitable separator or filter system to ensure that the delivered gas is sufficiently clean for use in the cargo chambers, and to prevent damages to any gas separating or adsorption equipment, shall be installed.

104 Compressor air intakes shall be located to ensure that contaminated air is not drawn into the compressors.

105 Exhaust of O₂ enriched gases shall be to safe locations on open deck.

106 Exhaust of N₂ enriched gases shall be to safe locations on open deck. See B306.

107 Any N₂ storage vessel shall be fitted with non-return valves on the inlet connections.

108 The N₂ delivery line shall be fitted with a safety relief valve

sized for the maximum delivery of the nitrogen generating equipment.

D 200 Carbon dioxide scrubbers

201 CO₂ scrubbers for atmosphere control, if fitted, will be specially considered.

E. Electrical Installations

E 100 General

101 All electrical installations shall comply with Pt.4 Ch.8.

E 200 Cable penetrations

201 Cable penetrations between cargo chambers and surrounding spaces, and between individual cargo chambers shall be arranged gas tight. The penetrations may be arranged with separate glands for each cable, or with boxes or glands filled with a suitable packing or molded material.

F. Instrumentation

F 100 General

101 For instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are additional to those given in Pt.4 Ch.9.

102 Indication, monitoring, logging and/or control of atmosphere quality in cargo area as well as of other functions required by this Section shall be arranged at a centralized control stand.

103 For cable penetrations, see E200.

F 200 Gas monitoring

201 For CA chambers equipment for measurement of O₂ and CO₂ contents in cargo chamber atmosphere shall be installed. At least one measuring point each for O₂ and CO₂ shall be arranged in any chamber which may be isolated from other chambers.

202 Equipment for logging of above parameters automatically during the entire length of the loaded voyage shall be installed. Gas monitors may be common with monitors for indication and alarm.

203 All normally accessible spaces, including cargo chambers not arranged for CA, which in case of leakage of bulkheads, doors, hatches, pipes, etc. may be filled with an atmosphere with reduced O₂ concentration, shall be fitted with equipment for measurement of O₂ content in the atmosphere. At least one measuring point shall be installed in each space. The sampling point shall be located with due regard to the ventilation arrangement for the space.

204 Discrete gas sensors may be installed locally at the respective points where measurement shall be taken, or a sampling system may be arranged, with sampling pipes led from points of measurement to a centralized gas monitor. One gas monitor each for O₂ and CO₂ is required.

205 When a sampling system with sequential analyzing is arranged, each sampling point shall be analyzed at intervals not exceeding 1 hour. Sampling time at each point shall be at least equal to 3 times pipe length divided by mean gas velocity in the connected sampling line, in order to ensure that a fresh gas sample is analyzed. Alternatively gas may be drawn continuously through all sampling lines.

Flow failure in the sampling lines shall be monitored. The sampling system shall be designed to function at any chamber pressure within pressure set points of pressure relief valves. The sampling lines shall be arranged for easy testing of tightness.

206 Common sampling lines for the measurement of O₂, CO₂ and refrigerant gas may be arranged.

207 O₂ and CO₂ analyzers shall have an accuracy of at least $\pm 0.1\%$ by volume or better. The oxygen analyzer(s) shall have a range of 0 to 21% O₂.

The CO₂ analyzer(s) shall have a range of at least 0 to 15% CO₂.

208 *Closeable penetrations into each chamber or space referred to in 201 and 203 and not utilizing any sampling lines for fixed gas analyzers required by 201 to 207, shall be installed in order to facilitate measurements of the quality of the atmosphere with portable gas analyzers in case the fixed equipment/ordinary sampling lines are out of order. At least two portable gas analyzers for O₂ and at least one portable gas analyzer for CO₂ shall be kept onboard.*

209 *All spaces adjacent to CA chambers and not arranged for normal access by personnel shall be arranged for use of the portable O₂ analyzers required in 208.*

F 300 Control of cargo chamber atmosphere

301 *Injection of nitrogen and removal of CO₂ may be arranged either manually or automatically in order to control chamber atmosphere. If automatic control is arranged, separate gas analyzing equipment shall be installed for this purpose.*

F 400 Alarm and monitoring

401 *An alarm system for monitoring of atmosphere in cargo area and other functions shall be installed according to Table F1. This alarm system may be integral with the ship's main alarm and monitoring system, but a proper grouping shall be arranged in order to separate from other types of alarm i.e. machinery alarms. This also covers extension alarms, which shall not disturb personnel without cargo responsibilities.*

Table F1 Alarm points		
Item	Alarm	Comments
O ₂ content, high	X	Each CA chamber/group
O ₂ content, low	X	Each CA chamber/group
O ₂ content less than 21%	X	Each space referred to in 203
CO ₂ content, high	X	Each CA chamber/group
Atm. pressure, high	X	Each chamber/group if external supply of N ₂ . Automatic closing of supply valve
Liquid seal, low level	X	Each liquid seal trap
Ventilation failure	X	Electric failure, each fan required by Sec.5
Compressor failure	X	Electric failure, all compressors for N ₂ generating equipment
Sampling lines, flow failure	X	All sampling lines
Gas sensors, failure	X	Out of normal range
Logger out of order	X	

G. Instruction Manual. Personnel Protection Equipment

G 100 Instruction manual

101 *An instruction manual giving comprehensive information about the following shall be available onboard:*

- *principal information about use of CA*
- *complete description of the ship's CA installation*
- *hazards caused by low oxygen atmospheres and consequential effects on human beings*
- *medical countermeasures in case of exposure to low oxygen atmosphere*
- *procedure for functional testing each time a portable gas separating/instrumentation unit is placed onboard. See A202*
- *operation, maintenance and calibration instructions for all types of gas detectors onboard*
- *instructions regarding use of portable O₂ analyzers with alarm for personal protection*
- *prohibition of entry of spaces under CA even with use of breathing apparatus*
- *instructions with regard to loading of all chambers under the same main hatch being completed prior to injection of nitrogen*
- *procedures for checking chambers and locking door/hatches prior to injection of nitrogen. Procedures for safe keeping of key by responsible officer*
- *a list of signboards fitted on all entrances to gas dangerous spaces including those signboards which shall be checked prior to a CA condition.*
- *procedures relating to connection and disconnection of hoses for N₂ when the double-block-and-bleed arrangement has been omitted in connection with a portable gas generating unit*
- *procedures for checking that all gas detectors are in operation and with correct alarm set points prior to injection of nitrogen*
- *gas freeing procedures for CA chambers*
- *procedures for checking completed gas freeing prior to entry of CA chambers*
- *instructions with regard to gasfreeing of all chambers under the same main hatch prior to entry*
- *instructions with regard to gasfreeing and atmosphere testing of spaces without fixed ventilation and fixed gas detection equipment.*

G 200 Personnel protection equipment

201 *At least 10 off portable O₂ analyzers with alarm and of a type designed to be continuously worn for personal protection are required to be available onboard.*

202 *At least one set of oxygen resuscitation equipment shall be available onboard.*

SECTION 6 TESTS

A. Pressure Tests of Components

A 100 General

101 *A hydraulic strength test and a pneumatic tightness test shall be carried out in the presence of the surveyor.*

102 *Hydraulic pressure tests may be carried out with any liquid, including water, unless it has an unfavourable effect on the refrigerant. Pneumatic pressure tests may be carried out with nitrogen, CO₂ or air.*

103 *The strength and tightness tests may after special consideration be combined into a single test.*

104 *The test pressure shall be as stipulated in Table A1, where HP and LP indicate design pressure on the high-pressure and low-pressure sides, respectively, as given in Sec.3 A500.*

Table A1 Test pressures		
Component	Hydraulic	Pneumatic
High-pressure side of the compressors such as cylinders, cylinder heads, shutoff valves, and pipes	1.5 x HP	1 x HP
Low-pressure side of the compressors such as crankcase, pipes and valves	1.5 x LP	1 x LP
High-pressure pressure vessels such as condensers, liquid receivers, oil separators, plate heat exchangers etc.	1.3 x HP	1 x HP
Low-pressure pressure vessels such as liquid separators for systems with pump circulation of the refrigerant, RSW coolers, brine coolers, etc. and other low pressure heat exchangers including air coolers, plate freezers and plate heat exchangers	1.3 x LP	1 x LP

A 200 Test pressures

201 The cooling water side of all machinery and equipment shall be hydraulically pressure tested at 1.5 times the working pressure of the cooling water pump, but not less than 5 bar.

202 The brine and RSW side of all machinery and equipment shall be hydraulically pressure tested at 1.5 times the working pressure, but not less than 5 bar. Open brine tanks and other tanks not under pressure in service, shall be examined for tightness.

B. Pressure Tests after Assembly

B 100 General

101 *The high-pressure side of the plant shall be tested pneumatically at a pressure of 1 x HP.*

102 *The low-pressure side of the plant shall be tested pneumatically at a pressure of 1 x LP.*

103 *Completed sub-assemblies («package» units) may be tightness-tested before fitting on board.*

104 Brine and RSW pipes shall be tested pneumatically at twice the working pressure of the pump, but not less than 5 bar.

B 200 Pressure tests after erection on board

201 *Pressure piping welded in place on board shall be subjected to a strength test at 1.3 times the design pressure. If pneumatic, this test may be a combined strength and tightness test.*

202 *The test required in 201 may be substituted by a pneumatic tightness test at 1.0 times the design pressure, provided all pipes and fittings with welded and soldered joints have previously been sub-*

jected to a hydraulic strength test at 1.5 times the design pressure.

B 300 Drying of the refrigerating plant

301

Guidance note:

After tightness testing and before charging with refrigerant it has been assumed that an extensive drying out (vacuumation) of the complete plant is carried out by the contractor. It is advised that pressure rise curves are recorded and analyzed to verify tightness and that the plant is dry. A satisfactory drying cannot be carried out at very low temperatures.

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C. Function and Capacity Testing of the Completed Installation

C 100 General

101 All systems, components and equipment shall be included in operational and capacity testing covering all design functions and all design operating conditions.

102 Special considerations shall be given when testing under low ambient temperatures. In such cases, heating of the chambers may be demanded.

103 A complete narrative test report with all recorded and calculated data shall be given to the surveyor.

C 200 Refrigerating machinery, operational test

201 All components of the refrigerating machinery shall be tested in operation. If deemed necessary, capacity tests of the components may be demanded.

202 The testing shall be carried out in accordance with an approved test program. The makers' adjustments and commissioning of the plant shall have been fully completed prior to the testing. The plant in its entirety shall perform satisfactorily and without hunting, instabilities or disruptions during the complete test program. Normal maintenance work including filter replacements or filter cleaning may be carried out during convenient periods of the testing.

203 The test program shall include cooling down procedures from ambient temperature to all design operating chamber (delivery air) temperatures with subsequent stable delivery air temperatures for periods of at least 2 hours.

204 The test program shall be worked out to ensure that all components and functions are tested including for example:

- compressor capacity control system
- refrigerant distribution between units
- oil return
- oil transfer between units
- defrosting
- operation with 2 or more different chamber temperatures simultaneously.

205 During the operational test the plant shall be operated in accordance with the operation manual as during normal operations.

206 During the cooling down- and stable periods relevant data shall be recorded at sufficiently short intervals to give relevant information of the ongoing process. The intervals are normally not to exceed 30 minutes during transient processes and 60 minutes during stable (stabilizing) periods.

207 RSW tanks shall be cooled down to the tank design temperature.

208 Tunnel freezers and plate freezers shall be tested by simulated operation.

209 Instrumentation and automation systems shall be tested. All alarm and automatic stop functions shall be tested. The accuracy and set point of all indicating instruments and all sensors for alarm and automatic stop functions shall be tested.

210 *Safety instrumentation, including automatic stop functions, refrigerant leakage detection systems, emergency stops, alarm call buttons etc. shall be tested on all vessels irrespective of class notations.*

C 300 Thermometers. Gas indicating equipment

301 All chamber, cooling air, freezing tunnel and RSW thermometers shall be tested for accuracy.

302 Equipment for measuring the CO₂ concentration in the chambers shall be tested.

C 400 Air circulation and air renewal systems

401 All fans for air coolers shall be tested. Dual or multi speed fans shall be operationally tested at all speeds and with applicable chamber temperature. Capacity testing is required only at full speed. Variable speed fans need only be tested at maximum speed and at the warmest chamber design temperature. The testing shall include measurements of the air flow, pressure difference across the fans, electrical frequency or rotational speed and power consumption. The resulting air circulation rates shall be calculated and recorded.

402 The air distribution within the chambers shall be checked.

403 All air renewal fans shall be tested. Dual or multi speed fans shall be tested operationally at all speeds. Capacity testing is required only at full speed. The testing shall include measurements of air flow, electrical frequency or rotational speed and power consumption. The resulting air renewal rates shall be calculated and recorded.

C 500 Chamber tightness test

501 On ships designed for carriage of bananas or fruit in general the tightness of the chambers (group of chambers) shall be verified and the leakage rate shall be measured and recorded.

C 600 Insulation and heat balance test

601 A thermographic investigation with infrared detecting equipment shall be carried out to verify the completeness of the insulation of the cargo chambers. For a series of two or more identical sisterships the thermographic investigation may on the 2nd and the following ships be replaced by an external cold spot inspection with regard to excessive condensation or frost deposits while the chambers are at their lowest design temperature.

602 The overall heat transfer coefficient of the insulation and sufficient overall refrigerating capacity shall be verified based on measurements taken during a heat balance test. All chambers shall be cooled down to approximately their lowest design operating temperature and normally at least 20°C below the mean ambient temperature. If the lowest design operating temperature is different between the chambers, this difference is as far as possible to be maintained during the heat balance test.

The chambers may be cooled down to the expected balance temperature as found practicable. When the expected balance temperature has been reached, the plant shall be run manually and as far as possible in accordance with the following:

- the ingoing sea cooling water temperature may be automatically controlled to a chosen set point within the design range
- the compressor(s) shall be run with constant and well de-

finied capacity. Only one of several identical compressors need be in operation

- each compressor shall be in operation together with the other components of the same unit. See Sec.3 A201
- automatic brine temperature controllers and chamber temperature controllers shall not be in operation.

The situation may be accepted as in balance when:

- the mean chamber temperature (measured by use of all installed chamber temperature sensors) for each individual chamber and for all chambers together for each hour of a 4 hour period have been changing less than 0.05°C/h
- the ambient weather conditions have remained stable for 6 hours
- there are no indications of an unstable or off-balance situation.

Chambers with the same design operating temperature shall have chamber balance temperatures preferably within a range of 1.5°C.

All data necessary for the verification calculations, see 700, shall be recorded hourly covering a period of at least 6 hours prior to the balance.

All heat input to the chambers (fan motors, lighting fixtures, heat tracing on drainpipes, etc.) shall be measured by a calibrated kW-meter. Use of A-meter with estimate of cosφ will not be accepted.

603 A heat balance test shall be carried out for RSW tanks.

C 700 Verification of refrigerating capacity

701 For all design operating conditions calculations shall be made to verify that the installation has sufficient refrigerating capacity. The refrigerating capacity may be taken from the compressor curves or data corrected as relevant. The heat transfer losses shall be based on the heat transfer coefficient calculated after the balance test. In case of different heat transfer coefficients for various areas, the overall coefficient shall be the same as the overall coefficient calculated after the balance test. Evaporating and condensing temperatures shall be estimated based on observations during the balance test and to be corrected in accordance with Sec.3 B201 and B404.

D. Testing of CA installations

D 100 General

101 *Each chamber or gastight group of chambers shall be individually pressure tested with air to the design overpressure to verify that the leakage rate does not exceed that specified in Sec.5 B104.*

102 *The nitrogen distribution system shall be hydraulically pressure tested to at least 1.5 times the relief valve setting but not less than 5 bar.*

103 *All other pipes or piping systems which in case of leakage may cause gas with low oxygen content to flow into cargo chambers or other enclosed spaces shall be tightness tested to at least 2 bar or by equivalent means confirmed to be tight.*

104 *N₂ release prealarm and inlet valve interlock arrangement shall be tested.*

105 Nitrogen generating equipment shall be tested with regard to capacity and quality of the delivered gas.

106 CO₂ scrubbers, if installed, shall be tested.

D 200 Instrumentation

201 *Upon completion of the installation, all functions shall be tested according to an approved test program. With regard to which of the testing requirements that are safety requirements applicable to all ships with CA installation, reference is made to the relevant installation requirement.*

202 *Gas detectors shall be tested for zero, span and linearity by means of certified test gas. In order to achieve this, three points shall be tested, preferably 0%, 50% and 100% of range.*

203 *Flow failure alarms for gas sampling lines shall be tested by blocking the relevant pipe manually. Gas sampling pipes shall be tested for tightness.*

204 Alarm setpoints are preferably to be tested by letting the measured parameter pass the setpoint value (may be done by means of process parameter calibrators). Where this is not pos-

sible, change of setpoint may be accepted for analog channels.

205 Automatic control functions may be tested by introducing setpoint changes and observing stable adaption to new value.

206 Operator interface (display/indicating) panels shall be checked for acceptable functionality and compliance with Pt.4 Ch.9.