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中国船级社
CHINA CLASSIFICATION SOCIETY

邮轮空调系统检验指南
**GUIDELINES FOR SURVEY OF
AIR-CONDITIONING SYSTEMS
ONBOARD CRUISE SHIPS**

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A BRIEF INTRODUCTION

The Guidelines have been developed for the purpose of providing a survey basis for the air-conditioning systems onboard cruise ships in accordance with the requirements for cabin climate control in CCS Rules for Cruise Ships.

The Guidelines are based on Design Rules for Heating Ventilation and Air-conditioning of Civil Buildings, ISO Cabin Air-conditioning and Ventilation, and related national and international rules and standards for air-conditioning systems onboard ships, also in conjunction with the actual operational conditions of cabin air-conditioning systems onboard existing cruise ships and large passenger ships/ro-ro passenger ships, by the analysis and research on main types, cooling/heating sources, configuration of units, air conditioning mode, system division and arrangement, product inspection, etc., of the existing air-conditioning systems onboard cruise ships.

The Guidelines contain mainly the requirements for plans and documents to be submitted, calculation and methods of system loads, inspection and approval of system design, configuration of units, air distribution, construction and arrangement, monitoring and safety, testing, units and equipment, etc.

The Guidelines apply mainly to central air-conditioning system of cabins required for indoor climate control onboard cruise ships applying for class notation CEDI (Cx).

The external temperature and humidity range of air-conditioning system may be determined by the applicant in the design according to the climate conditions of the routes for which the cruise ship is intended.

The air-conditioning systems of cruise ships applying for class notations of cabin climate comfort corresponding to different levels are to be in compliance with the relevant requirements of the Guidelines.

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Section 1 General Provisions

1.1 Scope of application

1.1.1 The Guidelines apply to central air-conditioning systems of cabins required for indoor climate control onboard cruise ships applying for class notation CEDI (Cx).

1.1.2 Ship's air-conditioning systems are to be capable of operating under various predetermined climatic conditions and meeting the requirements of cabin climate comfort level.

1.1.3 Ship's air-conditioning systems are to be so designed that the range of external temperature and humidity may be determined by the applicant according to the climate conditions of the routes for which the cruise ship is intended. The class notation of cabin climate comfort will be assigned together with the designed range of external temperature and humidity, which is valid only for the given range.

1.1.4 The application of refrigerant of air-conditioning system is to comply with the relevant requirements for prevention of air pollution from ships of MARPOL Annex VI and of the flag State Administrations. Ammonia refrigerant is not to be used for ship's air-conditioning systems.

1.1.5 Any materials containing asbestos are to be prohibited used for air-conditioning systems.

1.1.6 The certification requirements and product inspection of air-conditioning units and equipment are to be in compliance with the relevant provisions of Section 7 of the Guidelines.

1.2 Ambient conditions

1.2.1 Ship's air-conditioning systems are to be so designed and arranged as to comply with the requirements of Tables 1.2.1(1) and 1.2.1(2), to ensure its normal operation under the following conditions.

Ship's inclining angle **Table 1.2.1 (1)**

Inclining angle ^① (°)			
Transverse		Longitudinal	
Heeling	Rolling	Trim	Pitching
15	22.5	5 ^②	7.5

Notes: ① The transverse incline and longitudinal incline may occur simultaneously.

② If the length of ship is greater than 100m, the angle of trim may be taken as $500/L$, where L is the total length of ship, in m.

Ambient temperature **Table 1.2.1 (2)**

Ambient	Position	Temperature (°C)
Atmosphere	Indoors	0~45
	In special spaces or on machinery equipment	According to actual temperature in special spaces or equipment
	Weather deck	-25~45
Sea water	All	0~32

1.2.2 For cruise ships designed for specific routes in the restricted service, the ambient temperatures may be selected as per actual conditions of service area.

1.3 Definitions and terms

1.3.1 In addition to those specified in Chapter 5 of Rules for Cruise Ships, the definitions applicable to the Guidelines are as follows:

(1) Air-conditioning: means a form of air treatment whereby temperature, humidity, ventilation and air

cleanliness are all controlled within limits prescribed for the enclosure to be air-conditioned.

(2) Refrigerating unit: means the total of equipment, accessories, connecting pipes, etc., including the prime motor used for refrigeration cycle.

(3) Central-station air handling unit (hereinafter referred to as air-conditioning unit): means a form of air handling equipment consisting of various modules with air treatment functions.

(4) Air handling module: means a unit with the treatment functions of air mixing, purification, heating, cooling, dehumidification, humidification, damping, etc.

1.4 Plans and documents

1.4.1 The following plans and documents are to be submitted for approval:

(1) Arrangement of air-conditioner cabins for the whole ship;

(2) Schematic diagram of air-conditioning system;

(3) Schematic diagram of air-conditioning piping system (cooling water piping system, cooling/heating medium water piping system, heating piping system, humidifying piping system, etc.);

(4) Arrangement of air ducts for the whole ship;

(5) Schematic diagram of air-conditioning control system for the whole ship;

(6) List of monitoring, alarm, display and safety items;

(7) Mooring test and sea trial program;

(8) Other plans and documents as deemed necessary by CCS.

1.4.2 The following plans and documents are to be submitted for information:

(1) Design instructions for air-conditioning system (including specifications);

(2) Load calculations for air-conditioning system.

Section 2 Load Calculation

2.1 Indoor climate index

2.1.1 The indoor climate control requirements for different positions onboard cruise ships corresponding to comfort levels are referred to the relevant requirements of Section 3, Chapter 5 of Rules for Cruise Ships.

2.2 Load calculation requirements

2.2.1 In addition to the necessary calculation carried out at schematic design phase or preliminary design phase, calculation for cooling load in summer and heating load in winter is to be carried out for air-conditioning areas at detailed design phase.

The basic loading calculation method is given in 2.3 of the Guidelines, and the other calculation methods accepted by CCS may also be used.

2.2.2 The heat gain in summer for air-conditioning areas is to be determined by the following:

- (1) heat transmitted from external bulkheads;
- (2) solar radiation heat entering through external windows;
- (3) heat gain from persons;
- (4) heat gain from lighting;
- (5) heat gain from equipment, apparatus, conduits and other internal heat sources;
- (6) heat gain from foods and stores;
- (7) heat brought by fresh air;
- (8) other potential sensible heat and latent heat.

2.2.3 The cooling load in summer for air-conditioning areas is to be in compliance with the following:

- (1) The cluster coefficient of personnel, simultaneous usage coefficient, equipment power factor, coefficient of ventilation and heat preservation, etc., are to be taken into consideration in the calculation of cooling loads, such as human body, lighting, equipment, etc.
- (2) Where the stratified air-conditioning is used for large spaces, the product of integrated maximum value of cooling load of air-conditioning for the whole cabin multiplying by empirical coefficient being less than 1 may be taken as the cooling load for the air-conditioning areas.

2.2.4 The moisture gain in summer for air-conditioning areas is to be so calculated to select appropriate cluster coefficient of personnel, simultaneous usage coefficient, ventilation coefficient, etc., according to the moisture transfer categories respectively, and determined by the following:

- (1) moisture gain from persons;
- (2) moisture from wetted surface, liquid level or liquid flow;
- (3) moisture from foods;
- (4) other potential moisture diffusion rate.

2.2.5 The heating load in winter for air-conditioning areas is to be determined according to the following heat loss onboard cruise ships:

- (1) heat consumption of external bulkheads;
- (2) heat consumption of ventilation;
- (3) heat loss by other means.

2.2.6 The heating load in winter for air-conditioning areas is to be in compliance with the following:

- (1) If a cabin with temperature difference between the adjacent is equal to 5°C or above, heat transfer capacity passing through internal bulkheads, decks, etc., is to be calculated. However, if a cabin with temperature

difference between the adjacent is less than 5°C, the heat transfer capacity is to be calculated provided that the heat transfer capacity passing through the internal bulkheads, decks, etc., is more than 10% heating load of this cabin.

(2) Due to the actions of wind force outdoors, an additional 5% to 10% heat consumption is to be calculated for external vertical bulkheads.

(3) Where the height of cabin is more than 4 m, an additional 2% is to be calculated for each 1 m higher on the basis of that mentioned in above (2), however, the total additional rate is not to be greater than 15%.

2.3 Load calculation methods

2.3.1 Calculation for cooling load in summer

(1) The cooling load of air-conditioning system in summer is calculated by the following equation:

$$Q_{\text{sum}} = Q_c + Q_f + Q_v + Q_o$$

where:

Q_{sum} : total cooling loads of air-conditioning system in summer, in W;

Q_c : heat gain from air-conditioning cabins, in W;

Q_f : heat brought by fresh air system, in W;

Q_v : heat produced by air supply piping system, in W;

Q_o : other potential sensible heat and latent heat, in W.

(2) The heat gain from air-conditioning cabins is calculated by the following equation:

$$Q_c = Q_t + Q_e + Q_p + Q_{\text{food}}$$

where:

Q_c : heat gain from air-conditioning cabins, in W;

Q_t : external afferent heat, including the heat gain from containment structures and solar radiation heat entering through window glass, in W;

Q_e : heat gain from indoor equipment, including heat dissipating capacity of lighting, equipment, apparatus, pipes, stores and other internal heat sources, in W;

Q_p : heat gain from persons;

Q_{food} : food heat dissipation, in W;

① The external afferent heat is to be calculated by the following equation:

$$Q_t = \sum_{i=1}^n K_i \times A_i \times \Delta t_i + \sum_{j=1}^m G_{sj} \times A_{sj}$$

where:

n : number of containment structures for counting;

K_i : coefficient of heat transfer for containment structure, in $W/m^2 \cdot K$;

A_i : heat transfer area of containment structures for counting, in m^2 ;

Δt_i : difference of calculated temperature between indoor and outdoor, in K.

The difference of calculated temperature Δt for containment structures are to be calculated by:

$$\Delta t = t_w - t_n + \Delta t_r$$

where:

t_w : air temperature at the outside of cabin, in K;

t_n : air temperature at the inner side of cabin, in K;

Δt_r : radiation temperature rise on external surface, in K;

for weather containment structures without solar insolation, Δt_r is taken as 2 to 3 (K);

for weather containment structures with solar insolation,

$\Delta t_r = 12$ (K) for vertical light surfaces;

$\Delta t_r = 29$ (K) for vertical dark surfaces;

$\Delta t_r = 16$ (K) for horizontal light surfaces;

$\Delta t_r = 32$ (K) for horizontal dark surfaces.

If the adjacent cabin is an air-conditioned room, and the air temperature difference is less than 3°C, the cooling load of this part may not be taken into account.

m: number of windows for counting;

G_{sj} : window solar radiation heating rate, in W/m²;

350 W/m² for single-layer common glass window;

240 W/m² for single-layer common glass window provided with interior shading;

300 W/m² for double-layer common glass window;

210 W/m² for double-layer common glass window with interior shading;

A_{sj} : heat transfer calculation area of glass window, in m².

② Body heat dissipation is calculated by the following equation:

$$Q_p = n_p \times (q_{ps} + q_{pL})$$

where:

n_p : number of personnel inside the cabin for counting;

q_{ps} : per capita body sensible heat, in W, within the range of 55 to 65 W according to activity;

q_{pL} : per capita body latent heat, in W, within the range of 75 to 155 W according to activity.

③ Food heat dissipation is calculated by the following equation:

$$Q_{food} = n_p \times (q_{fs} + q_{fL})$$

where:

n_p : number of personnel inside the cabin for counting;

q_{fs} : per capita food sensible heat, in W, generally taken as 8.5 W;

q_{fL} : per capita food latent heat, in W, generally taken as 8.5 W.

(3) The heat gain from fresh air is to be calculated by the following equation:

$$Q_f = \frac{a \times \rho_a \times q_v \times (i_w - i_n)}{3.6}$$

where:

Q_f : heat brought by fresh air, in W;

a: fresh air ratio, dimensionless;

ρ_a : air density, in kg/m³;

q_v : air supply volume of air conditioner, in m³/h;

i_w : outdoor design air enthalpy, in kJ/kg;

i_n : indoor design air enthalpy, in kJ/kg;

(4) Heat generated by air supply piping system is to be calculated by the following equation:

$$Q_v = Q_d + Q_s + Q_r$$

where:

Q_v : heat generated by air supply piping system, in W;

Q_d : heat produced by fan, in W;

Q_s : air temperature rise heat inside air supply duct, in W;

Q_r : air temperature rise inside air return duct, in W.

- ① The heat produced by fan is calculated by:

$$Q_d = \frac{P_f \times q_v}{3600 \times \eta_f \times \eta_n \times \eta_m}$$

where:

P_f : full air pressure of fan, in Pa;

q_v : air supply volume of air conditioner, in m^3/h ;

η_f : total pressure efficiency of fan;

η_n : transmission efficiency, taken as 0.95 for belt transmission, and taken as 1 for direct transmission or fan motor not in the airflow;

η_m : efficiency of motor, generally taken as 0.85 to 0.9 for motor in the airflow, and taken as 1 for motor not in the airflow;

- ② The air temperature rise heat inside air supply duct is calculated by:

$$Q_s = \frac{C_a \times \rho_a \times q_v \times \Delta t_d}{3.6}$$

where:

C_a : air constant-pressure specific heat, in $kJ/kg \cdot K$, generally to be defaulted as $1.0056 kJ/kg \cdot K$;

ρ_a : air density, in kg/m^3 ;

q_v : air supply volume of air conditioner, in m^3/h ;

Δt_d : air temperature rise, in K inside air supply duct, to be taken within the range of 1 K to 2 K.

- ③ The air temperature rise heat inside air return duct is calculated by:

$$Q_r = \frac{(1 - a) \times C_a \times \rho_a \times q_v \times \Delta t_r}{3.6}$$

where:

a : fresh air ratio, dimensionless;

C_a : air constant-pressure specific heat, in $kJ/kg \cdot K$, generally to be defaulted as $1.0056 kJ/kg \cdot K$;

ρ_a : air density, in kg/m^3 ;

q_v : air supply volume of air conditioner, in m^3/h ;

Δt_r : air temperature rise, in K inside air return duct, to be taken within the range of 2 K to 3 K.

2.3.2 Calculation for desiccant load in summer

- (1) The moisture load in summer is to be calculated by the following equation:

$$D_{sum} = D_f + D_p + D_{food} + D_w + D_o$$

where:

D_{sum} : total desiccant loads in air-conditioning cabin areas in summer, in kg/h ;

D_f : desiccant load of fresh air, in kg/h ;

D_p : body moisture dissipating load, in kg/h ;

D_{food} : food moisture dissipating load, in kg/h ;

D_w : moisture loads of wetted surface, liquid level or liquid flow, in kg/h ;

D_o : other potential moisture loads, in kg/h .

- (2) The moisture load of air fresh is calculated by the following:

$$D_f = 0.001 \times a \times \rho_a \times q_v \times (d_w - d_n)$$

where:

- Q_f : moisture load of fresh air, in kg/h;
 a : fresh air ratio, dimensionless;
 ρ_a : air density, in kg/m³;
 q_v : air supply volume of air conditioner, in m³/h;
 d_w : outdoor design air moisture, in g/kg;
 d_n : indoor design air moisture, in g/kg.

(3) The body dissipating moisture load is to be calculated by the following equation:

$$D_p = 0.001 \times g \times n_p$$

where:

- D_p : body dissipating moisture load, in kg/h;
 g : per capita body dissipating moisture each hour, in g/h;
 n_p : number of personnel inside the cabin for counting.

(4) The moisture load due to evaporation of liquid level is calculated by:

$$D_w = A \times g$$

where:

- D_w : moisture loads of wet surface, liquid level or liquid flow, in kg/h;
 A : evaporated surface area for the calculated period, in m²;
 g : unit evaporation on water surface, in kg/m² · h.

2.3.3 Calculation for heating load in winter

(1) The heating load of air-conditioning system in winter is to be calculated by the following equation:

$$Q_{win} = Q'_t + Q'_f + Q'_o$$

where:

- Q_{win} : total heating loads of air-conditioning system in winter, in W;
 Q'_t : heat transferred to the external, including the heat conducted by containment structures, in W;
 Q'_f : heating load brought by fresh air, in W;
 Q'_o : heat loss by other means in W.

(2) The heat transferred to the external is to be calculated by the following equation:

$$Q'_t = \sum_{i=1}^n K_i \times A_i \times \Delta t'_i$$

where:

- n : number of containment structures for counting;
 K_i : coefficient of heat transfer for container structure, in W/m² · K;
 A_i : heat transfer calculation area of container structure, in m²;
 $\Delta t'_i$: difference of calculated temperature between indoor and outdoor, in K;

The difference of calculated temperature Δt for containment structure is calculated by:

$$\Delta t'_i = t'_n - t'_w$$

where:

- t'_n : air temperature at inner side of cabin, in K;
 t'_w : air temperature at outside of cabin, in K.

(3) The heating load brought by fresh air is to be calculated by the following equation:

$$Q'_f = \frac{a \times \rho_a \times q_v \times (i'_n - i'_w)}{3.6}$$

where:

Q'_f : heating load brought by fresh air, in W;

a : fresh air ratio, dimensionless;

ρ_a : air density, in kg/m^3 ;

q_v : air supply volume of air container, in m^3/h ;

i'_n : outdoor design air enthalpy, in kJ/kg ;

i'_w : indoor design air enthalpy, in kJ/kg .

2.3.4 Calculation for humidification load in winter

(1) The humidification load in winter is calculated by:

$$D_{\text{win}} = \frac{a \times \rho_a \times q_v \times (d'_n - d'_w)}{1000} - \frac{n_p \times \Delta d'}{3600} - A \times g$$

where:

D_{win} : total humidification load in winter air strainer, kg/h ;

a : fresh air ratio, dimensionless;

ρ_a : air density, in kg/m^3 ;

q_v : air supply volume of air conditioner, in m^3/h ;

d'_n : indoor design air moisture, in g/kg ;

d'_w : outdoor design air moisture, in g/kg ;

n_p : number of personnel inside the cabin for counting;

$\Delta d'$: per capita integrated moisture dissipation inside the cabin in winter for each hour, in kg/h , generally taken as 0.08 kg/h ;

A : evaporated surface area, in m^2 , of open water surface inside the cabin;

g : unit evaporation on water surface, in $\text{kg/m}^2 \cdot \text{h}$.

2.3.5 Calculation for air supply volume

(1) The air supply volume of air conditioner is to be calculated by the following equation:

$$q_v = \max(q_f, q_{\text{sum}}, q_{\text{win}})$$

where:

q_v : calculated value of air supply volume for air conditioner, in m^3/h ;

q_f : calculated value of air supply volume to meet the requirements of number of fresh air changes, in m^3/h ;

q_{sum} : calculated value of air supply volume required by cooling load in summer, in m^3/h ;

q_{win} : calculated value of air supply volume required by heating load in winter, in m^3/h .

(2) The air supply volume to meet the requirements of number of fresh air changes is to be calculated by the following equation:

$$q_f = \frac{\sum_{i=1}^n n_{pi} \times v_i + \sum_{j=1}^m f_j \times V_j}{a}$$

where:

q_f : air supply volume to meet the requirements of number of fresh air changes, in m^3/h ;

n : number of cabin spaces calculated according to per capita minimum fresh air volume outside for each hour;

n_{pi} : number of personnel inside the cabin for counting;

v_i : per capita minimum fresh air volume outside for each hour in the cabin for counting, in m^3/h ;

m : quantity of cabins for counting the number of fresh air changes per hour;

f_j : number of fresh air changes per hour, in $1/\text{h}$, required by the cabin for counting;

V_j : volume of cabin spaces for counting, in m^3 ;

a : fresh air ratio, dimensionless.

Note: For cabins requiring both fresh air for persons and number of fresh air changes, to be taken as the greater.

(3) The air supply volume required by cooling load in summer is to be calculated by the following equation:

$$q_{sum} = \frac{3.6 \times Q_c}{C_a \times \rho_a \times \Delta T}$$

where:

q_{sum} : calculated value of air supply volume required by cooling load in summer, in m^3/h ;

Q_c : heat gain in air-conditioning cabin, in W;

C_a : air constant-pressure specific heat, in $kJ/kg \cdot K$, generally to be taken as $1.0056 kJ/kg \cdot K$;

ρ_a : air density, in kg/m^3 ;

ΔT : design temperature difference, in K, of air supply volume for air conditioner in summer, generally to be taken as 10 K.

(4) The air supply volume required by heating load in winter is to be calculated by the following equation:

$$q_{win} = \frac{3.6 \times Q'_c}{C_a \times \rho_a \times \Delta T'}$$

where:

q_{win} : calculated value of air supply volume required by heating load in winter, in m^3/h ;

Q'_c : heating load in air-conditioning cabin, in W;

C_a : air constant-pressure specific heat, in $kJ/kg \cdot K$, generally to be taken as $1.0056 kJ/kg \cdot K$;

ρ_a : air density, in kg/m^3 ;

$\Delta T'$: design temperature difference, in K, of air supply volume for air conditioner in summer, generally to be taken not greater than 22 K.

Section 3 System Design and Construction

3.1 General requirements

3.1.1 The air-conditioning system is to be so designed to comply with the requirements for refrigerating (heating) capacity, air volume, air velocity, humidity, fresh air/air return ratio and arrangement of cabins onboard ships.

3.1.2 The refrigerating units (or heat exchangers) are to be normally operated within the range of specified air strainers, the refrigerating (or heating) capacity and energy regulation are to be capable of meeting the operational requirements for design air strainers of air-conditioning system.

3.1.3 The materials used for air-conditioning systems are to be in compliance with the relevant requirements of CCS Rules for Materials and Welding.

3.1.4 The piping of air-conditioning system, such as cooling water piping, cooling/heating medium water piping, humidification piping, etc., is to comply with the applicable requirements of Chapter 2, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.

3.1.5 The ventilation ducts of air conditioners are to be so designed and arranged to comply with the relevant requirements for ventilation system in Chapter II-2 of SOLAS.

3.2 Refrigerating units and cooling water system

3.2.1 The refrigerating (heating) capacity of refrigerating unit (or heat exchanger) and single refrigerator is to be so selected to comply with the load variation rules for air conditioning and regulating requirements for partial load operation.

3.2.2 The refrigerating units (or heat exchangers) of central air-conditioning system are to be so provided to ensure that the loads of other refrigerating units (or heat exchangers) comply with the requirements of climate control index for all specified cabins in the event of a failure of any one refrigerating unit (or heating exchanger).

3.2.3 Where the refrigerating units (or heating exchangers) are not connected in common to all air-conditioning units, the refrigerating capacity of the unit (or heat exchanger) serving each air-conditioning unit is to comply with the requirement of 3.2.2.

3.2.4 In principle, each refrigerating unit of central air-conditioning system is to be provided with an independent cooling water pump, or otherwise, at least two independent cooling water pumps are to be provided to ensure the air-conditioning system is capable of operating normally by the other pump in the event of a failure of any one pump.

3.2.5 The sea water cooling system of refrigerating units is to be so arranged to ensure that sufficient cooling water is available under any ship's operating conditions likely to be occurred.

3.3 Cooling/heating medium water system and air-conditioning units

3.3.1 Where the cooling/heating medium water is circulated in the central air-conditioning system by pumps, in principle, each air-conditioning unit (or heat exchanger) is to be provided with an independent cooling/heating medium water pump, or otherwise, at least two independent cooling/heating medium water pumps are to be provided to ensure the air-conditioning system is capable of operating normally by the other pump in the event of a failure of any one pump.

3.3.2 The cooling/heating medium water piping system is to be capable of effectively regulating the inlet cooling/heating medium water temperature or flow of air-conditioning units, and expansion tanks are to be

provided for closed piping system.

3.3.3 Stop valves and temperature indicators are to be provided for cooling/heating medium water inlet and outlet pipes of air-conditioning units. De-aeration and draining device are to be provided for the cooling/heating medium water pipes.

3.3.4 For the air-conditioning units which may freeze in winter, anti-freezing measures are to be taken for heating medium water coils.

3.3.5 Where the air velocity of cooling coils for air-conditioning units at windward is greater than 2.5 m/s, a water defector is to be provided for air-conditioning units.

3.3.6 Air filtration is to be provided for air-conditioning units and the filter is to facilitate for cleaning and renewal.

3.4 Air handling system

3.4.1 Central air-conditioning units are generally to be provided respectively for the central air-conditioning systems according to fire-protection, functions, port and starboard sides, etc., The air handling system areas are normally to be divided in accordance with the following principles:

(1) the cabins located nearby and cabins with same or similar indoor parameters are to be divided as an identical area;

(2) the public spaces and accommodation cabins are to be divided separately, other than the same area;

(3) the air-conditioning system used for cabins emitting noxious gases is to be independent from those used for other cabins;

(4) the central air-conditioning units and air duct systems are to be independent in different main vertical zones.

3.4.2 In general, the hospital is to be provided with independent air-conditioning units, or otherwise, a non-return flap is to be provided for supply air ducts extending to hospital.

3.4.3 The exhaust systems from the following spaces are to be fed directly to the open deck, and not used for recirculation (except for those specially designed). Additionally, the exhaust systems for each space or each area are to be separate from each other:

(1) hospital;

(2) public toilets;

(3) laundries;

(4) pantries, etc.

3.4.4 The hospital and pantries are to be maintained less negative pressure than the adjacent cabins.

3.4.5 In laundries and drying and ironing rooms, exhaust air devices are to be installed over areas with high heat emission and high humidity.

3.4.6 Stratified air handling system can be used for the large spaces where the personnel activities are only in the lower part.

3.4.7 The fresh air of air handling system is to be in compliance with the following requirements:

(1) The air change flow is not to be less than that required by the personnel, and that used for compensating the exhaust or that used for maintaining the indoor positive pressure, which is the greater.

(2) Air inlets are to be provided with means being capable of closing. **Air inlets are to be provided with closable devices. Fresh air inlets are generally to be equipped with adjusting device**, so as to meet the needs of air volume variation in winter, summer and seasonal transition respectively.

(3) The fresh air inlets are to be so located to comply with the following requirements:

- ① outdoors with cleaner air;
- ② preventing from short circuit of air intake and exhaust.

3.4.8 The air handling system with independent temperature and humidity control is to comply with the following requirements:

- (1) The air change flow is to be calculated in accordance with the sanitary and dehumidification requirements, to be taken as the greater.
- (2) The indoor humidity is to be monitored and measures are to be taken to prevent the condensation on the surface of equipment.

3.4.9 The maximum air supply volume of central air handling system is to be determined by the integrated maximum value of cooling load for the system, and the minimum air outlet is to be determined by the factors, such as load changing range and sanitary conditions of cabin, positive pressure, air distribution, range of variable air volume terminal unit, etc., and not to be less than the designed air change flow.

3.4.10 The indoor air within air-conditioning areas is to be kept at a certain positive pressure, generally to be 5 Pa, and not to be more than 50 Pa as the maximum.

3.5 Air distribution

3.5.1 The indoor air distribution and circulation are to prevent from local stagnating as far as possible.

3.5.2 The air supplying method in air-conditioning areas and outlets are to be so selected to comply with the following requirements:

- (1) Lateral air supply, such as shuttle outlet, slot outlet, etc., is generally to be provided to form attached airflow. However, lateral air supply is not to be used in the event that the equipment blocks it or the air outlet per unit area is larger and the air velocity is required in occupied zones.
- (2) Where the hang ceiling can be used, round, rectangle and strip air diffusers or orifice plates for air supply are to be applied respectively according to the height of air-conditioning area and airflow required by usage spaces. Where the air outlet per unit area is larger and the required air velocity in occupied zone is less or the requirement of temperature difference in the area is stricter, orifice plates are to be used for air supply.
- (3) Nozzle outlet, swirl diffuser or lower air supply may be selected for larger air-conditioning areas.
- (4) For the higher spaces with large indoor residual heat, such as studio room, etc., telescopic cylinder downward air supply mode may be selected for use.
- (5) The air supply terminal devices of central air handling system are to ensure that the indoor air distribution is not affected by the variety of air volume, and meet the basic temperature and air velocity requirements in air-conditioning areas.
- (6) The surface temperature of air outlets is to be 1°C to 2°C higher than indoor dew-point temperature. If it is lower than the indoor dew-point temperature, low temperature air outlets are to be applied.

3.5.3 The requirements for air supply methods are to be as follows:

(1) Lateral air supply with attached airflow is to comply with the following requirements:

- ① Where the distance between upper edge of air outlet and ceiling is large, flow deflectors with upward inclined 10° to 20° are to be provided at air outlets.
- ② Flow deflectors not to cause jetting deviation (left and right) are to be provided within the air outlets.
- ③ No obstacles in the jet flow.

(2) Orifice plate for air supply is to comply with the following requirements:

- ① The height of plenum space above orifice plate is to be determined by calculation, but the net height is not less than 0.2 m.

- ② The air supply velocity to the plenum space is generally to be of 3 to 5 m/s. Except for the longer jet flow of air supply, branch pipes may not be provided within plenum space. Flow deflectors or baffles are generally to be fitted at air outlets in order to prevent air flow directly blow towards orifice plate.
 - ③ The orifice plate is to be so arranged to be suitable for indoor local heat sources.
- (3) Nozzle air supply is to comply with the following requirements:
- ① The occupied zones are to be located in air recirculating areas.
 - ② The installation height of nozzle is to be determined in accordance with the factors, such as the height of air-conditioning area and location of recirculating area.
 - ③ Where combined to use as heating, the nozzle is to be capable of changing the jetting flow angle.
- (4) Air diffuser is to comply with the following requirements:
- ① The air outlet is to be so arranged to facilitate the induction of ambient air by supply air flow, and the distance between center of diffuser and sidewall is generally not to be less than 1.0 m.
 - ② No obstacles along the horizontal air supply direction of diffuser.
 - ③ Where combined to use as heating and the installation height is larger, the diffuser is generally to be capable of changing the jet flow state.
- (5) Displacement ventilation is to comply with the following requirements:
- ① The distance between floor and hang ceiling is to be greater than 2.7 m.
 - ② The air outlet temperature is not to be lower than 18°C.
 - ③ The cooling load treated by system is to be not greater than 120 W/m².
 - ④ No larger heat source and stronger flow disturbance indoors.
 - ⑤ The vertical indoor temperature gradient is to be less than 2 k/m.
 - ⑥ Not to be used in the identical space with other air supply and exhaust systems.
- (6) Under-floor air supply is to comply with the following requirements:
- ① The air outlet temperature is not to be less than 16°C.
 - ② The air stratification height is to be maintained above the personnel breathing area indoors.
 - ③ The relative humidity of under-floor air supply is to be controlled under 80%.
 - ④ The floor plenum chamber is to be well sealed and have good thermal insulation and moisture resistance to the surrounding cabin structural members.
 - ⑤ Not to be used in the identical space with other air supply and exhaust systems.
- (7) The air distribution of stratified air handling system is to be so designed to comply with the following requirements:
- ① Bilateral air supply is generally to be applied for air-conditioning areas, and unilateral air supply may be used if the span of air-conditioning areas is less than 18 m, the air return outlet is generally to be located under the same side of air supply outlet.
 - ② Multiple parallel jet flows are to be overlapped with each other. If bilateral jet flows are applied, the shot range may be calculated by 90% distance of the center of nozzles at both sides.
 - ③ Heat transfer from air-conditioning areas to non-air-conditioning areas is to be reduced. Where necessary, air supply and exhaust devices are to be provided in non-air-conditioning areas.

3.5.4 The positions of air return outlets and exhaust outlets are to be determined by the factors, such as influences on occupied zones, winter and summer air strainers and net height of air-conditioning cabin, etc., and comply with the following requirements:

- (1) Not to be located in air supply jet flow areas and the places where personnel is often occupied. Where lateral air supply is applied, the air return outlet is generally to be located under the same side of air supply outlet.

- (2) Where the height of cabin is larger and thermal air is supplied in winter, or orifice plate and diffuser downward air supply is applied, the air return outlet is generally to be provided in the lower part of the cabin.
- (3) Where the air return is supplied from ceilings within the air-conditioning areas mainly for cooling air in summer, the air return outlet in the ceiling is generally to be combined with lighting.
- (4) Air return is not to be supplied directly from hang ceiling in the event that cabins are located on the top floor or larger heat gain above the hang ceiling or larger space of hang ceiling.
- (5) Air return through corridor, if available, may be applied if there are multiple air-conditioning cabins along the corridor, however, the air velocity of cross section for corridor is not to be excessive.
- (6) Where the displacement ventilation method is applied, the air return outlet is to be located above the height of occupied zones and the exhaust outlet is to be higher than air return outlet.

Section 4 Control, Alarm and Safety Systems

4.1 General requirements

4.1.1 In addition to the requirements of this Section, the control, the alarm and safety systems of air-conditioning units are to be in compliance with the applicable requirements of PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships.

4.2 Display and alarm

4.2.1 The refrigerating compressor units are to be provided with the following displays and/or alarms in the central control station of engine room or other manned control stations:

- (1) exhaust pressure and temperature;
- (2) inlet-air pressure and temperature;
- (3) lubricating oil pressure difference (except for those without lubricating oil pumps);
- (4) unit working state;
- (5) unit shut-down due to failure;
- (6) refrigerant leakage;
- (7) condenser inlet and outlet temperatures and pressures;
- (8) evaporator inlet and outlet temperatures and pressures.

4.2.2 The cooling/heating medium water systems are to be provided with the following displays and/or alarms in the central control station of engine room or other manned control stations:

- (1) water temperature and pressure at inlet and outlet of cooling medium coils;
- (2) water temperature and pressure at inlet and outlet of heating medium coils;
- (3) temperature and pressure at inlet and outlet of heat exchanger primary and secondary sides;
- (4) temperature and pressure (or pressure difference) of sub-water catcher;
- (5) pressure at inlet and outlet of pump;
- (6) differential pressure of water filter;
- (7) start and stop conditions of heat exchangers, valves, pumps, etc.

4.2.3 The cooling water system is to be provided with the following displays and/or alarms in the central control station of engine room or other manned control stations:

- (1) inlet and outlet pressures of cooling water pump (sea water pump);
- (2) working state of cooling water pump (sea water pump);
- (3) failure of cooling water pump (sea water pump).

4.2.4 The air handling system is to be provided with the following displays and/or alarms in the central control station of engine room or other manned control stations:

- (1) air temperature and humidity;
- (2) outlet pressure and inlet and outlet temperatures of water spraying room;
- (3) static pressure difference between inlet and outlet of air strainer;
- (4) working state of equipment, such as fans, pumps, humidifiers, etc.

4.3 Control system

4.3.1 The air-conditioning units are to be capable of being controlled automatically and manually.

4.3.2 Under the refrigeration working condition, the electrical control system is to ensure that the compressors and cooling water pumps, if any, are to be interlocked. The compressors are not to be operated

until the pumps are started, and compressors are to automatically stop after the pumps are shut down in the event of a failure.

4.3.3 Under the thermal working condition, the electrical control system is to ensure that the fans are to be interlocked with heaters. The heaters are not to be operated until the fans are started, and fans are to be delayed to stop after the heaters are shut down.

4.3.4 A local emergency stop button is to be provided for refrigerating compressor unit and air handling system so as to disconnect the power source of equipment in the event of failure or leakage of refrigerant.

4.3.5 The refrigerating compressor units are to be provided with the following safety protection and displayed in the central control station of engine room:

- (1) automatic shutdown where the air-inlet lateral pressure is too lower;
- (2) automatic shutdown where the exhaust pressure and condenser pressure are too higher;
- (3) automatic shutdown where the lubricating oil pressure is too lower.

4.3.6 Measures are to be taken for central air-conditioning systems to maintain the temperature and humidity of cabins in a specified range.

Section 5 System Layout

5.1 System layout

5.1.1 The air-conditioning system units and equipment are to be so arranged to be readily accessible for servicing and maintenance. A sufficient space is to be provided in way of installation places of condensers and evaporators so as to facilitate for cleaning and pipe renewal.

5.1.2 The air-conditioning system unit rooms are to be mechanically ventilated effectively. The inlet ducts of ventilation system are to be made of steel or other equivalent materials, and the exhaust outlets are to be located in a space which will not cause a hazard. The refrigeration machinery rooms are to be provided with exhaust fans, of which the suction of exhaust piping is to be fitted in the lowest position of the room.

5.1.3 The air-conditioning units, central air-conditioning units, fans, heat exchangers, ducts, etc., are to be capable of being periodically maintained, inspected, cleaned or renewed. The ventilation ducts are to be provided with hatches for inspection and cleaning, and with necessary draining cocks.

5.1.4 Water drip pans and draining ports are to be provided under the air-conditioning system equipment and accessories where condensate water is possibly generated, and to ensure no condensate water will overflow in the event of the ship's inclining and rolling.

5.1.5 The air ducts are to be prevented from passing through non-air-conditioning cabins as far as possible, particularly those for bathrooms, shower rooms, toilets, galleys, etc. Where the ducts have to pass through these cabins, the effective insulation and anti-moisture measures are to be taken.

5.1.6 The air ducts are to be prevented from being installed, as far as possible, above the computers, control panels, electronic equipment, generators, switchboards, transformer terminal equipment, etc. Where it is unavoidable, such pipes therefrom are to be of watertight type or drip-proof type, and the pipe joints are to be avoided being located above the equipment.

5.2 Anti-vibration, noise control and insulation

5.2.1 The noise of air-conditioning system spreading to its usage spaces and surrounding spaces are to comply with the ship's noise level as required. Where necessary, the effective means of sound silencing or sound insulation are to be provided.

5.2.2 Fans are to be provided with vibrating isolation devices.

5.2.3 Effective vibrating isolation is to be provided for the installation of refrigerating units, pumps, air-conditioning units, air ducts, etc., so that the vibration transmitting to the air-conditioning spaces and surrounding spaces are to comply with the ship's vibration level as required.

5.2.4 Effective insulation is to be provided for the equipment and pipes which need to reduce cold/thermal losses or for the external surfaces with the temperature higher than 60°C. The insulation materials are to be non-toxic, free from extraneous odour, non-hygroscopic and flame retardant.

5.2.5 Filtration, soundproofing, vibration isolation and insulation materials are to comply with the relevant requirements of Chapter II-2 of SOLAS.

Section 6 Test

6.1 Hydraulic test and tightness test

6.1.1 The hydraulic test and tightness test of air-conditioning piping system are to comply with the applicable requirements of Chapter 2, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.

6.2 Mooring test and sea trial

6.2.1 Upon completion of ship's air-conditioning systems, a mooring test and sea trial are to be carried out to verify their effectiveness and conformity. The mooring test and sea trial programs are to be submitted to CCS site Surveyor for approval before commencement. Such test programs are at least to include the following:

- (1) ship's navigational conditions during the test;
- (2) operation conditions required by air-conditioning equipment;
- (3) testing items;
- (4) indoor climate parameters required for measurement and verification, positions of measuring points and measuring instruments (the measurement requirements are given in Appendix 1 of Rules for Cruise Ships);
- (5) persons in charge of test.

6.2.2 Upon completion of the mooring test and sea trial, test reports are to be submitted to CCS. The test reports are at least to include the following:

- (1) ship's navigational conditions during the test;
- (2) outdoor climate conditions;
- (3) operation conditions of air-conditioning equipment;
- (4) test results of the items;
- (5) position, time and data of each measuring points for verified indoor climate;
- (6) details of measuring instruments;
- (7) persons in charge of test.

6.2.3 The mooring test and sea trial items are to refer to Table 6.2.3.

Test items of air-conditioning system		Table 6.2.3	
No.	Test items	Mooring test	Sea trial
		Mechanical compression refrigerating system	Mechanical compression refrigerating system
1	Operational tests of cooling/heating medium water pumps and cooling water pumps	X	—
2	Commissioning of refrigerating units	X	—
3	Commissioning of air-conditioning units	X	—
4	Operation test of air-conditioning system	X	X

Notes: X — required; — — not required.

Section 7 Approval of Units and Equipment

7.1 Scope of application

7.1.1 This Section applies to approval and inspection for electric-driven marine mechanical compression cold water air-conditioning units, the other types of marine air-conditioning/heating pump units may also refer to this Section.

7.2 Definitions and terms

7.2.1 Refrigerating unit: means the sum of equipment accessories, connecting pipes, etc., to complete the refrigeration cycle, including the prime motor.

7.2.2 Refrigeration capacity of unit: means the heat absorbed by refrigerant in unit evaporators from cold water within the unit time.

7.2.3 Nominal working condition: means the condition corresponding to the nominal parameters (generally marked in relevant standards, product labels or samples).

7.2.4 Coefficient of performance (COP): means the ratio between refrigeration capacity under nominal working conditions and total input power.

7.3 Main parts and components

7.3.1 The main parts and components mean the compressors, safety valves, expansion valves, electric motors, condensers, evaporators, oil separators, liquid receivers, other pressure vessels, ventilators, etc.

7.3.2 A strength test is to be carried out upon the fabrication of each part and component of unit subject to the pressure of refrigerant, and the pressure test report is to be reviewed and confirmed by CCS Surveyor or the test is to be witnessed by CCS Surveyor on site.

7.3.3 Where the main parts and components are purchased, the applicants are to establish a complete subcontractor control means so as to ensure the quality, and the purchased main parts and components are to have the relevant quality certificates. The pressure vessels and motors are to be made by the manufacturers approved by CCS.

7.3.4 The following parts and components are to be inspected by CCS and furnished with CCS marine products certificates:

- (1) heat exchangers (evaporators, condensers, etc.);
- (2) pressure vessels (design pressure ≥ 0.7 MPa or volume ≥ 0.25 m³);
- (3) refrigerating compressors;
- (4) electrical control boxes;
- (5) motors (≥ 50 kW).

7.3.5 The list of certification requirements for units is given in Table 7.3.5.

List of certification requirements for units

Table 7.3.5

No.	Product name	Document		Approval mode				Plan approval	Remark
		C/E	W	DA	TA-B	TA-A	WA	PA	
1	Heat exchanger (evaporator, condenser, intercooler)	X	–	–	–	–	–	X	
2	Pressure vessel	O	X	–	–	–	X	X	<0.7 MPa & 0.1 ~ 0.25 m ³ , WA to be provided for W, ≥ 0.7 MPa or ≥ 0.25 m ³ , C/E to be provided
3	Refrigerating compressor	X	–	–	X	–	–	X	

No.	Product name	Document		Approval mode				Plan approval	Remark
		C/E	W	DA	TA-B	TA-A	WA	PA	
4	Motors (50 kW and over)	X	—	—	X	O	—	X	
5	Motors (below 50 kW)	—	X	—	X	—	—	X	
6	Electrical control box	X	—	—	—	—	—	X	

Notes: X — required; — — not required; O — optional.

7.4 Plans and documents

7.4.1 The applicants are to submit the following plans and documents of air-conditioning units to CCS for approval:

- (1) specifications of main product performance (design temperature, design pressure, maximum working pressure, medium, nominal heat exchanging area, flow of cooling water, grade of vessel and pressure of pneumatic test);
- (2) plan of general assembly;
- (3) plan of main parts and components, including cross-section of refrigerating compressors and detailed dimensioned plans of reciprocating compressor crankshafts;
- (4) plans of condensers, air coolers, oil separators, liquid receivers and other pressure vessels;
- (5) schematic diagrams of main system, safety and alarm units (schematic diagrams of automatic control, safety and alarm system);
- (6) list of physical and chemical properties for main parts and components;
- (7) test program of product type approval.

7.4.2 The applicants are to submit the following plans and documents of air-conditioning units to CCS for information:

- (1) calculations for refrigerating capacity;
- (2) product specifications and nameplates, certificate of inspection (in Chinese and English).

7.5 Assessment of welding procedures

7.5.1 Where the pressure vessels, such as unit evaporators, condensers, etc., are made by the manufacturer itself and applied by welding structures, the welding procedures are to be assessed by CCS before manufacture in accordance with the relevant requirements of CCS Rules for Materials and Welding.

7.5.2 Where the pressure piping is applied by welding (if applicable), the welding procedures are to be assessed by CCS before manufacture in accordance with the relevant requirements of CCS Rules for Materials and Welding.

7.6 Design technical requirements

7.6.1 The units are to be capable of being operated under the following conditions:

- (1) at inclining and rolling conditions with long-term heeling angle of 15 °, long-term trimming angle of 5 °, rolling angle of 22.5 ° and pitch angle of 7.5 °;
- (2) ambient temperature: 0 ~ 45°C for indoors, -25 ~ 45°C for weather decks and actual temperature for other special spaces;
- (3) moist air, salt mist, oil mist and mold;
- (4) within the range of voltage -10% ~ +6% and frequency ±5%.

7.6.2 Materials

(1) The materials of pressure vessels for refrigerants are to comply with the relevant requirements for Class II pressure systems and of Chapter 3, PART ONE of CCS Rules for Materials and Welding, and the minimum

design pressure is to comply with the requirements of Table 7.6.2.

Minimum requirements for design pressure **Table 7.6.2**

Refrigerants	Design pressure at high pressure side (MPa)	Design pressure at low pressure side (MPa)
R134a	1.4	1.1
R404a	2.48	2.01
R407C	2.35	1.9
R410A	3.45	2.8
(1) The parameters of other refrigerants may refer to the relevant standards, and the design pressures of refrigerating units at high pressure side and low pressure side are not to be less than 56 °C and 46 °C respectively. (2) The refrigerants are to be so selected to comply with the requirements of the flag State Administrations or of MARPOL Annex VI. (3) Ammonia refrigerants are not to be used for air-conditioning systems onboard cruise ships.		

(2) The physical and chemical properties of seamless steel pipes and copper pipes for liquid receivers, condensers, evaporators, etc., are to comply with the relevant requirements of Chapters 6 and 9, PART ONE of CCS Rules for Materials and Welding.

(3) The materials of parts and components for air-conditioning units are to be such that they are not liable to deterioration due to the action of refrigerant, lubricating oil and their mixtures, as to ensure the normal operation of the units.

(4) The materials contacting sea water are to have sufficient corrosion resistance.

- ① the selection of materials for unit plating and piping is to comply with the relevant requirements of Chapters 2 and 6, PART THREE of CCS Rules for Classification of Sea-going Steel Ships and of the relevant marine standards;
- ② anti-corrosion boards are to be provided for the end covers and water chambers of unit heat exchanger (evaporator, condenser) contacting sea water, with specified resistance to corrosion for fastening plating;
- ③ plastic coating or other corrosion resistance methods are to be provided for cast iron or carbon steel end covers, etc., contacting sea water.

(5) Thermal insulation materials, including protective layer, thermal insulating layer, adhesive, etc., are to be of low flame spread.

7.6.3 Main parts and components

(1) The strength and manufacture of unit pressure vessels are to comply with the requirements of Chapter 6, PART THREE in CCS Rules for Classification of Sea-going Steel Ships.

(2) The calculation, material selection and manufacture of crankshafts and crank arms of refrigerating compressors are to comply with the relevant requirements of Chapter 2, PART FIVE of CCS Rules for Classification of Sea-going Steel Ships.

(3) The basic performances of electrical control boxes, such as ambient temperature, ambient humidity, vibration condition, power supply fluctuation, electromagnetic compatibility, mold, salt fog onboard, etc., are to comply with the relevant requirements of Chapter 2, PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships.

7.6.4 Unit performances

(1) Design working condition

The design temperature and flow under unit nominal working condition, maximum load condition, low-temperature working condition, variable working condition are given in Table 7.6.4(1).

Unit design temperature and flow condition

Table 7.6.4(1)

Item	Outlet temperature at cooling medium water side, in °C	Unit refrigerating capacity water flow at cooling medium water side, in m ³ /h.kW	Inlet temperature at cooling water side, in °C	Unit refrigerating capacity water flow at cooling water side, in m ³ /h.kW
Nominal working condition	7	0.172	32 ^a /36 ^b	0.268
Maximum load condition	15	0.172	35/-	0.268
Low-temperature working condition	5	0.172	19/-	0.268
Variable working condition	5~15	0.172	19~35/36	0.268
a. The cooling water is sea water.				
b. The cooling water is the fresh water in central cooling water system.				

(2) Coefficient of performance (COP) under nominal working condition

The refrigerating COP under unit nominal working condition is not to be less than the value as required in Table 7.6.4(2).

Refrigerating COP

Table 7.6.4(2)

Inlet temperature at cooling water side	32 ^a			36 ^b		
Piston type unit COP	≥3.7			≥3.4		
Screw type unit refrigerating capacity, in kW	<173	173~346	>346	<173	173~346	>346
Screw type unit COP	≥3.8	≥4.2	≥4.4	≥3.5	≥3.65	≥3.8
a. The cooling water is sea water.						
b. The cooling water is the fresh water in central cooling water system.						

(3) Performance under nominal working condition

Units are to be operated under the nominal working conditions specified in Table 7.6.4(1), with their performances, such as refrigerating capacity, power consumption, refrigerating COP, water side pressure loss, etc., in compliance with the following requirements:

- ① the refrigerating capacity is not to be less than 97% of the nominal value;
- ② the refrigerating power consumption is not to be greater than 110% of the nominal value;
- ③ the refrigeration COP is not to be less than 92% of the indicating value, which is to comply with the requirements of Table 7.6.4(2);
- ④ the pressure losses of cooling medium water and cooling water via units are not to be greater than 110% of the indicating value.

7.6.5 Safety protection

(1) Where the units are operated automatically, manual controls are also to be provided so that manual control can be effected in the event of failure of the automatic control.

(2) The units are to be at least provided with the following protective measures to automatically shut down the compressors in the following events:

- ① excessively low pressure at the suction side of compressors;
- ② excessively high pressure at the delivery side of compressors and excessively high pressure in condensers;
- ③ excessively low lubricating oil pressure in compressors;
- ④ failure of sea water cooling circulating pumps;
- ⑤ excessively low temperature at outlet of evaporator.

(3) The units are to be provided with the following safety protection measures:

- ① the refrigerating compressors are to be interlocked with cooling water pumps and cooling medium water pumps;
- ② protection against motor overload, lack of phase, electrical short-circuit and power phase sequence;

- ③ the refrigerating systems are to be provided with emergency relief devices;
- ④ where open-type refrigerating compressors are applied, shields are to be provided for couplings or other exposed rotating machinery parts;
- ⑤ the units are to be provided with thermometers and pressure gauges, to indicate the pressures of cooling water/cooling medium water and the inlet, exhaust of compressors as well as lubricating oil.

7.6.6 Alarm

The units are to be provided with the following audible and visual alarms:

- (1) alarm for high temperature at outlet of cooling water of condensers;
- (2) alarm for high exhaust pressure/low suction pressure/low oil pressure (except for oil pumps without lubricating);
- (3) alarm for failure of sea water cooling circulating pump;
- (4) alarm for compressor shut-down in the event of failure;
- (5) alarm for leakage of refrigerants;
- (6) alarm for low temperature at outlet of evaporators.

7.6.7 Relief valve

- (1) A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve. The safety devices are to come into action in case of excessive refrigerant pressure, the discharge being led to the suction side of the compressor. No closing appliances are to be permitted in the backflow pipes.
- (2) The opening pressure or bursting pressure of relief valves and/or safety discs of compressors is to be not greater than the design pressure of high pressure side.
- (3) All pressure vessels or other components of air-conditioning units which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, the discharge being led to a safety place above deck. Pressure gauges showing intermediate pressure are to be fitted between the safety discs and relief valves in series.
- (4) Where the power of the compressor prime mover does not exceed 10 kW, the relief valves and/or safety discs at the delivery side of the compressor may be omitted.
- (5) In the fluorine-substituted hydrocarbon systems, the safety valves and safety discs may be substituted by fusible plugs having a fusion point of 65°C, provided that the individual capacity of the above-mentioned pressure vessels is less than 100 l.

7.7 Type test

7.7.1 Test requirements

(1) Measuring instruments

The thermometers, pressure gauges, flowmeters and electrical instrument lamps are to be calibrated and used within the period of validity, with the precision meeting the test requirements.

(2) Test condition: non-condensable gas in the test system is to be exhausted before testing to confirm no leakage of the refrigerants. Sufficient refrigerant and lubricating oil used for maintaining the normal operation of compressors are to be retained in the system. The pressure and temperature of suction and exhaust ports of compressors are to be measured at the same measuring point, which is located in way of straight pipe 0.3 m distanced from suction and gas delivery stop valves. The wind velocity around the test system and device is recommended not exceeding 2.5 m/s.

(3) The tolerance of test temperature and flow readings for units is to be in compliance with the requirements of Table 7.7.1.

Tolerance of temperature and flow measurement

Table 7.7.1

Items	Outlet temperature at cooling medium water side, in °C	Unit refrigerating capacity water flow at cooling medium water side, in m ³ /h.kW	Inlet temperature at cooling water side, in °C	Unit refrigerating capacity water flow at cooling water side, in m ³ /h.kW
Nominal working condition	±0.3	±5%	±0.3	±5%
Maximum load condition	±0.5		±0.5	
Low-temperature working condition				

(4) Except for noise testing, the pumps are not connected with electric power when the units with pumping system are being tested.

(5) Calculation of refrigerating capacity.

The refrigerating capacity is a net value, to be determined by test results, and not to be corrected within the range of allowable fluctuation under test working conditions. The calculation method of refrigerating capacity is to be in accordance with that for liquid secondary refrigerant specified in GB/T 10870-2014, with the equation as follows:

$$Q_n = Cq_m(t_1 - t_2) + Q_c$$

where: Q_n – unit net refrigerating capacity, in W;

C – specific heat capacity of water under mean temperature, in J/kg. °C;

q_m – cold water mass flow;

t_1 – cold water inlet temperature of evaporator, in °C;

t_2 – cold water outlet temperature of condenser for evaporator, in °C.

7.7.2 Strength test and tightness test of components

(1) Test requirements: strength test and tightness test are to be carried out upon the completion of fabrication of each part and component for refrigerating systems subject to refrigerant pressure, and the test pressure and time are given in Table 7.7.2.

(2) A hydraulic test of 1.5 P is to be carried out for the components subject to salt water or cooling water pressure, however, the test pressure is not to be less than 0.34 MPa.

(3) Test results: no leakage of oil or air, no pressure drop, no abnormal sound and obvious deformation found.

Strength, tightness pressure and time requirements

Table 7.7.2

Parts or components	Strength test (hydraulic)	Tightness test (airtight)
Pressure vessel	1.5 P/15 min	1.0 P/24 h
Compressor (cylinder, crankcase)	1.5 P/15 min	1.0 P/24 h
Valve or fitting	2.0 P/15 min	1.0 P/24 h
Pressure piping, welded manifold	1.5 P/15 min	1.0 P/24 h

Note: P is the design pressure. Nitrogen is generally used for tightness test. Where practicable, other alternative methods of tightness test may also be taken into consideration.

7.7.3 Tightness test for units

(1) A leak test is to be carried out for refrigerating systems under normal refrigerant charge, by means of refrigerant/helium leak detectors with the following sensitivity: 1×10^{-6} Pa m³/s for units with nominal refrigerating capacity equal to or less than 150 kW, and 1×10^{-5} Pa m³/s for units with nominal refrigerating capacity more than 150 kW.

(2) The single-point leakage rate at the side of refrigerant is to be less than 14 g/a.

7.7.4 Nominal working condition test

(1) Test methods: the units are to be operated under the nominal operating conditions as close as possible, and inspection is to be carried out for units operating condition, sensitivity and reliability of safety protection device, checking whether the temperature and the action of control elements, such as electrical appliances are in normal order, focusing on whether the components affecting the reliability of system, such as compressor oil return device, refrigerant liquid level, etc., are in normal order, and calculating the refrigerating capacity, power consumption and COP.

(2) Test results: the refrigerating capacity, power consumption and COP are to comply with the requirements of 7.6.4(3).

7.7.5 Maximum load condition test

(1) Test methods: the test voltage is the rated one, and the unit is to operate 1 h continuously after it runs stably under maximum refrigerating condition specified in Table 7.6.4(1), then to start operating again for 1 h after shutting down for 3 min (the voltage rise is not to exceed 3% during this period of time).

(2) Test results: the unit is to meet the following conditions:

- ① the unit is to operate normally, with no faults occurred throughout the test;
- ② the unit is to be capable of continuously operating, with no action occurred by motor overload protective device or other protective devices.

7.7.6 Low-temperature condition test

(1) Test methods: the test voltage is the rated one, and the unit is to operate 6 h continuously under low-temperature condition specified in Table 7.6.4(1).

(2) Test results: the unit is to operate normally, with no disconnection of the protective devices and no damage to the unit.

7.7.7 Noise test

(1) Test methods: the unit is to operate at rated voltage, rated frequency and under the nominal refrigerating working conditions as close as possible, and the noise is to be measured by reference to the method of rectangular parallelepiped measuring surfaces specified in Section 5, Chapter 2, PART 3 of CCS Guidelines for Control and Measurement of Noises for Ships and Marine Products, with 9 basic measuring points.

(2) Test results: the surface sound pressure level and sound power level are to be calculated by reference to the method of sound pressure level averaged over measurement surface specified in Section 5, Chapter 2, PART 3 of CCS Guidelines for Control and Measurement of Noises for Ships and Marine Products, the result being lower than the unit indicating value.

7.7.8 Water side pressure loss

(1) Test methods: water pressure values are to be taken by sampling from steady current section of cooling medium water and cooling water inlet and outlet pipes in the process of performance under nominal working condition, the calculating differences being the pressure losses of cooling medium water and cooling water via unit respectively.

(2) Under nominal working condition, the pressure losses of cooling medium water and cooling water via unit are not to be greater than 110% of the indicating values.

7.7.9 Variable working condition test

(1) Test methods: the flow and temperature of other conditions under nominal working condition when a certain condition in the operation under variable working condition for actions specified in Table 7.6.4(1) is varied. This test is to include the temperature condition points under the corresponding nominal working condition, maximum operating condition and minimum operating condition.

(2) The test results are to be plotted into curve or table, and each curve or table is to consist of values not less than four measuring points.

7.7.10 Inclination and rolling test

(1) Test methods: test is to be carried out at the most unfavorable inclining and rolling angles in accordance with the requirements of 7.1, in conjunction with the actual installation conditions, and the test is to be performed under the nominal working condition.

(2) To inspect whether the unit operation condition, sensitivity and reliability of safety protective devices, test temperature, action of control elements, such as electrical appliances are in normal order.

(3) Test is to be carried out on a scaled down (simplified) prototype made by the manufacturer.

7.7.11 Vibration test

(1) Test methods: the unit is installed on a platform, and the vibration value of mounting platform is less than 10% of the maximum value of the unit when it runs. Test is to be carried out for the unit under nominal operating condition, at that time the revolution and voltage of motor are to be maintained as the rated values. The vibration measuring points are to be located below the compressors in way of lower part of frame and arranged in axial direction, vertical axial direction and level vertical axial direction, respectively. The unit vibration value is to be the maximum among the measuring points.

(2) The position of measuring points for the maximum vibration value is to be indicated in the test report.

7.7.12 Electrical test

(1) High voltage test

① Test methods: basic sine-wave voltage with the frequency of 50 Hz is to be applied between unit live parts and accessible parts for 1 min, with test voltage being 1800 V;

② Test results: No breakdown and flashover.

(2) Protection against electric shock and grounding resistance measurement

The unit is to be equipped with reliably earthing device and protective device for preventing electric shock, of which the level of protection is at least to meet the requirements of GB4701 Grade I, and the earthing resistance values are not to exceed 0.1 Ω .

(3) Leakage current

① Test methods: to be tested in accordance with the requirement of 16.2 of GB4706.1-1992 in the condition that the nominal refrigerating capacity of unit is not more than 24.5 kW;

② The leakage current of unit bared metal parts and power lines is not to exceed 2 mA /kW rated input power.

(4) Temperature rise test

① Test methods: to be measured at accessible parts and heating parts of enclosure by thermocouple wire or point thermometer at rated voltage and under nominal working condition;

② Test results: the temperature at accessible parts and heating parts of enclosure is not to be higher than 60°C, with no abnormal temperature rise of other parts.

7.7.13 Automatic control equipment (electrical control box) test

The automatic control equipment is to be so tested to comply with the requirements of CCS Guidelines for Type Approval Test of Electric and Electronic Products. The specific test items are as follows: visual inspection, performance test, insulation resistance test, power supply failure test, vibration test, dry heat test, low-temperature test, cyclic damp heat test, salt mist test (if applicable), enclosure test and high voltage test.

7.8 Approval and inspection of units

7.8.1 Initial approval

The all following test items, if applicable, are generally to be carried out for initial approval:

(1) strength test and tightness test of components;

- (2) tightness test for units;
- (3) nominal working condition test;
- (4) maximum load condition test;
- (5) low-temperature working condition test;
- (6) noise test;
- (7) water side pressure loss test;
- (8) variable working condition test;
- (9) inclination and rolling test;
- (10) vibration test;
- (11) electrical test;
- (12) automatic control equipment (electrical control box) test.

7.8.2 Exemption of test items

Partial test items may be applied for exemption in written to CCS provided that the following conditions are met:

- (1) The manufacturer applying for approval can provide the recent test reports for relevant test items issued by technical authoritative institution (i.e. the State Bureau of Quality and Technical Supervision or the National Defense Science and Technology Laboratory, etc.).
- (2) The manufacturer applying for approval can provide the recent test reports for relevant test items signed by IACS member societies.
- (3) If the product is made by the manufacturer applying for approval in a mode of technology transfer from other works or authorization, and has been type approved by CCS when it was produced by the manufacturer which carried out technology transfer or authorization, inclination and rolling test may be dispensed with after the manufacturing capabilities, processing/assembly level of the applicant have been examined and assessed.

7.8.3 Reapproval for renewal of certificate

Where there is no change to the design of product and no change to the technical requirements for such products in CCS Rules for Classification of Sea-going Steel Ships, the type approval test may in general be dispensed with. However, CCS reserves the right to require a retest.

7.8.4 Unit/batch inspection after approval

The items of unit/batch inspection for products made by manufacturers obtaining CCS type approval B are as follows:

- (1) The inspection is to be carried out in accordance with the approved plan (relevant contents in quality control plan) obtained at approval, however, to include at least tightness test for units, nominal working condition test and noise test.
- (2) The above-mentioned tests may be independently completed by the manufacturer and the complete test reports are to be submitted to the Surveyors for review.
- (3) The Surveyors are, according to the principle of 5% sampling from same type unit for each batch or one unit as a minimum, to select partial products of units at random to carry out reinspection for the above-mentioned test items or to witness on site during the test made in the manufacturer.
- (4) Quality certificates of raw materials for main parts and components and strength test records for the batch are to be submitted to CCS Surveyors for review together with the application for each unit/batch inspection.

7.8.5 Unit/batch inspection without approval

The unit/batch inspections for the products made by manufacturers not approved by CCS are to be carried out unit by unit as per test items listed in 7.8.1 and witnessed by the attending Surveyors on site.