Guideline No.M-07 (201610)

M-07

REFRIGERATING PLANT

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Foreword

CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed mp@ccs.org.cn.

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Main changes:

The “5 material and components” is amended to coordinate with the rules.

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REFRIGERATING PLANT

1 Application

1.1 This Guideline applies to cargo refrigerating plants for refrigerated cargo carrier and may be taken as a reference for other refrigerating plants (e.g. refrigerating plant for food storage, ship-mounted central air conditioning system) in relevant chapters about pressure vessels.

1.2 The applicable main structures of compression-type cycle refrigerating plants are as follows:

(1) Compressor (piston refrigerating compressor, screw refrigerating compressor, centrifugal refrigerating compressor);

(2) Oil separator (where applicable);

(3) Condenser;

(4) High pressure liquid reservoir;

(5) Throttle valve;

(6) Evaporator;

(7) Gas-liquid separator (where applicable).

2 Basis for approval and inspection

2.1 Part Five, Chapters 1 and 2 of Part Seven of *Rules for Classification of Sea-Going Steel Ships*;

2.2 Annex VI of MARPOL73/78

2.3 *Rules for Material and Welding*

3 Terms and definitions

For the purpose of this Guideline, the following terms and definitions given in the above rules and standards are used therein:

3.1 Unit refrigerating capacity: A value obtained under the nominal condition by multiplying the specific enthalpy of the refrigerant vapor at the unit suction inlet minus that of the liquid refrigerant at the outlet by the refrigerant mass flux of the compressor.

3.2 Compression-type refrigeration cycle: A cycle composed of four processes including liquid evaporation or isobaric heat absorption of gases; compression of vapors or gases; vapor liquefaction or isobaric heat release of gases; and liquid throttling or gas expansion.

3.3 Nominal condition: A condition corresponding to the nominal parameter (generally indicated in the related standard, or on the nameplate or sample).

3.4 Standard condition: A condition specified for unified measurement of the refrigerator performance.

3.5 Refrigerant: Liquid in the refrigerating system that transfers heat through phase change, absorbs heat at low temperature and low pressure, and releases heat at high temperature and high pressure.

3.6 Positive displacement refrigerating compressor: A refrigerating compressor intended to increase the pressure of refrigerant gas or vapor by reducing the internal volume of the compression chamber.

3.7 Centrifugal refrigerating compressor: A refrigerating compressor intended to increase the gas pressure and velocity by means of the impeller which acts on gases, and then in the diffuser converts the kinetic energy of gases into the pressure energy.

3.8 Screw refrigerating compressor: A refrigerating compressor intended to compress gases by rotating one or two rotors (screws) with a spiral groove in the cylinder.

3.9 Condenser: A kind of heat exchanger in which the compressed gaseous refrigerant is liquefied by transferring heat to the external cooling medium.

3.10 Evaporator: A kind of heat exchanger in which the decompressed liquid refrigerant is evaporated after the heat is absorbed by cooling medium.

3.11 Liquid reservoir: A container in the refrigerating system that is used for storing liquid refrigerant.

3.12 Expansion valve: A valve which allows adjustment of refrigerant flow and provides throttling effect.

4 Plans and documents

4.1 Applicants are to submit the following plans and documents for the refrigerating plant to the CCS for approval:

(1) Main product performance specification table (design temperature, design pressure, maximum operating pressure, medium, nominal heat exchange area, container level, gas test pressure, list of materials).

(2) General assembly plan.

(3) Plans of main parts and components, including the sectional plan of refrigerating compressor, plans of reciprocating compressor crankcase (e.g. homemade), condenser, air and brine coolers, oil separator, liquid reservoir and other pressure vessels.

(4) Schematic diagrams of main systems and security alarm devices (automatic control, security and alarm systems).

(5) A list of physicochemical properties of main parts materials.

(6) Main acceptance criteria for NDT and hydraulic test.

(7) Product factory test program.

4.2 Additionally, applicants are to submit the following plans and documents for information:

(1) Refrigerating capacity calculation book (only for refrigerated cargo installation).

(2) Product operation instructions and nameplate, certificate of inspection (in both Chinese and English).

5 Materials and components

Materials and components are to comply with relevant requirements of CCS Rules.

6 Welding procedures qualification

Welded structures of such pressure vessels as the evaporator, condenser of the refrigerating plant are to be subject to the welding procedures qualification by the CCS according to *Rules for Materials and Welding* before being manufactured.

7 Design and technical requirements

7.1 Strength calculation of pressure vessels are to comply with Chapter 6, Part Three of *Rules for Classification of Sea-going Steel Ships*.

7.2 Design angle of inclination of the refrigerating plant in normal operation: Long-term heeling: 15 °, long-term trimming: 5 °, rolling: 22.5 °and pitching: 7.5 °.

7.3 Materials of pressure vessels for R717 and R22 refrigerants for the refrigerating plant are to comply with the regulations of CCS *Rules for Material and Welding* concerning Level II pressure vessels, and the design pressure is to comply with Table 7.3.

Table 7.3

Refrigerant	High-side design pressure (MPa)	Low-side design pressure (MPa)
R717 (ammonia)	2.2	1.7
R22	2.2	1.7
R134a	1.4	1.1
Parameters of other refrigerants may be selected according to relevant standard.		

7.4 Automatic control of the refrigerating plant: A refrigerating plant furnished with automatic control is to still provide a manual control mechanism which may be activated once the automatic control fails.

7.5 The automatic monitoring equipment of the refrigerating plant is to have such basic performances as ambient temperature and humidity, vibration condition, mains fluctuation, onboard salt mist, oil mist, mould and dust environment) compliant with Chapter 2, Part Seven of *Rules for Classification of Sea-going Steel Ships* (2009).

7.6 Automatic monitoring of the refrigerating plant is to:

(1) control the temperature in the refrigerated cargo hold within the preset low temperature range;

(2) ensure the temperature of cold air from the duct outlet not below the minimum allowable temperature when the air cooler cools the cargo hold;

(3) ensure that automatic temperature-controlling equipment may be bypassed and shut off when the automatic temperature control is switched to manual control. However, two automatic temperate-controlling valves may be arranged as an alternative measure, either of which is to be capable of fulfilling all the necessary functions when the other one fails.

7.7 Detection and alarming of the refrigerating plant are to provide visible and acoustic signals at an appropriate station (room).

Table 7.7

No.	Item	Display content	Alarm
1	Air temperature of refrigerated cargo hold	Temperature	High and low
2	Failure of air-cooling circulating fan	----	Failure
3	Bilge water level of refrigerated cargo hold	----	High
4	Condenser outlet cooling water temperature	Temperature	High

Continued Table 7.7

5	Failure shutdown of refrigerating compressor	----	Shutdown
6	Oil pressure of refrigerating compressor	Pressure	Low
7	Suction side pressure of refrigerating compressor	Pressure	Low
8	Discharge pressure of refrigerating compressor	Pressure	High
9	Failure of seawater-cooling circulating pump	----	Failure
10	Ammonia refrigerant leak of refrigerator room	----	Leak
11	Brine cooler inlet and outlet	Temperature	High (outlet)
12	Failure of brine circulating pump	----	Failure
13	Brine tank level	----	Low
14	Water chilling unit evaporator outlet	Temperature	Low

7.8 For safety protection of the refrigerating plant, a safety system is to be provided so as to automatically stop when:

(1) the refrigerating compressor has too low pressure at the suction side;

(2) the refrigerating compressor has too high discharge pressure and the condenser has too high pressure;

(3) the refrigerating compressor has too low oil pressure;

(4) the refrigerator room has ammonia leakage with concentration not reaching the explosion concentration;

(5) the seawater-cooling circulating pump fails;

(6) the water chilling unit has too low temperature at the outlet.

7.9 Safety valve of the refrigerating plant

7.9.1 A safety valve and/or safety membrane is to be arranged between the refrigerating compressor and other discharge line valve. Where the refrigerant pressure is too high, the safety valve is to open and/or the safety membrane is to burst to enable the refrigerant to flow back to the suction line. No closing device is allowed on the return pipe.

7.9.2 The compressor safety valve and/or safety membrane is to have the opening or bursting pressure no greater than the high-side design pressure.

7.9.3 The safety membrane and safety valve are to be provided in series for all pressure vessels and other components of the refrigerating system which may be filled with liquid refrigerant and would be turned off, and these components are to discharge to a safe position above the deck. A pressure gauge indicating the intermediate pressure is to be provided between the safety membrane and safety valve in series.

7.9.4 Where the refrigerating compressor prime mover has its power not exceeding 10 KW, the provision of safety valve and/or safety membrane is not necessary at the compressor discharge end.

7.9.5 For systems using fluorocarbon refrigerants where the aforesaid vessels have the capacity of less than 100 L, the safety membrane and safety valve may be substituted with a fusible plug with fusion point of 65 ℃.

7.9.6 A proper safety valve is to be provided where the discharge pressures of the cooling water and brine circulating pumps that are respectively at the cooling water side of the condenser and the brine side of the evaporator exceed their design pressures.

8 Refrigerating plant test

8.1 Inspection of pressure vessel and housing and tube heat exchangers (e.g. liquid reservoir, condenser, evaporator, intercooler) of the refrigerating plant.

8.1.1 Recheck of steel plate: The physicochemical properties are to be compliant with Chapter 3, Part One of *Rules for Material and Welding*.

8.1.2 Recheck of seamless steel pipe (R717) and copper pipe: The physicochemical properties are to be compliant with Chapters 6 and 9, Part One of *Rules for Material and Welding*.

8.1.3 Specimen: One specimen is to be welded for each pressure vessel to the stock length allowing the retest specimen to be taken.

Table 8.1.3

Specimen name	**Compression housing**	
Deposited metal tension	Level I	Level II
Forward bending	Required	Required
Reverse bending	Required	Required
Transverse tension of joints	Required	Required
Macroscopic examination of sections	Required	Required
Impact test	Required	---

Where the test panel is more than 20 mm thick, a side bend specimen is to be taken for the side bend test.

8.1.4 Strength and tightness tests: Parts and components of the refrigerating system that are under the refrigerant pressure, after being manufactured, are to be subject to the strength and tightness tests under the pressures as listed in Table 8.1.4:

Pressures for strength and tightness tests **Table 8.1.4**

Part or component		**Strength test (Hydraulic)**	**Tightness test (Airtight)**
Pressure vessel		1.5 P①	1.0 P
Compressor	Cylinder	1.5 P	1.0 P
	Crankcase	1.5 P	1.0 P

Continued Table 8.1.4

Valve or accessories	2.0 P	1.0 P
Pressure line, welded header, etc.	1.5 P	1.0 P

① 1.5 P air pressure test is of the same effect.

P is the design pressure, and the tightness test is generally performed with compressed air by immersing the component in the water or using other alternative when feasible. Components under brine or cooling water pressure are to go through the 1.5 P hydraulic test under the pressure no less than 0.34 MPa.

8.2 Compressor test:

8.2.1 Regulations for measuring instrument and accuracy: One or more types of test instruments may be used in measurement, provided that they are within the effective service life and have a certificate calibrated by the national metrological service or related department.

8.2.2 Test requirements

Remove non-condensable gas from the test system and confirm no refrigerant leaks. The system is to provide sufficient refrigerants and lubricating oil required for normal operation of the compressor.

Measurement of the pressure and temperature at the compressor suction and discharge ends is to be carried out at the same point which is to be at the straight pipe 0.3 m from the suction and discharge line valves.

No abnormal air movement is allowed around the test system (device).

The test device is to have an ambient temperature of (30 ± 5 ℃)

An installation is to be provided for oil measurement and extraction of refrigerant-oil mixture sample.

8.2.3 Performance test

The compressor performance test may be carried out by using X or Y method, and measurement is required for both methods.

Deviation between the results provided by the two methods is to be controlled within ± 4%, and the average of the measured values is to prevail.

During the compressor test, the system is to establish thermal equilibrium and the test duration is generally to be 1.5 h at least. Measured data is to be recorded half an hour after the test condition

is stabilized, and measurement is to be performed every 20 min, with deviation compliant with Table 8.2.3.

Data deviation **Table 8.2.3**

Test parameter	Maximum allowable deviation between each measured value and specified value	Maximum allowable deviation between any reading of measured value and the average
Suction pressure	±1.0%	±0.5%
Discharge pressure	±1.0%	±0.5%
Suction temperature	±3.0℃	±1.0℃
Shaft speed	±3.0%	±1.0%
Voltage	±3.0%	±1.0%
Frequency	±2.0%	±1.0%

8.2.4 Test data to be recorded include the ambient temperature, atmospheric pressure; compressor suction/discharge pressure and temperature, rotating speed or frequency, oil pressure and temperature; supply voltage, frequency, motor input power; cooling water inlet and outlet temperature and flow;

8.2.5 Selection of test method: Selection of X or Y method is to be in accordance with GB/T 5773-2004 *The Method of Performance Test for Positive Displacement Refrigerant Compressors*.

8.3 Test of automatic control equipment

The test is to be in accordance with *Rules for Classification of Sea-going Steel Ships*.

Test items:

(1) Visual inspection

(2) Performance test

(3) Insulation resistance measurement

(4) Power failure test

(5) Vibration test

(6) Dry heat test

(7) Low temperature test

(8) Cyclic damp heat test

(9) Salt mist test

(10) Enclosure protection test

(11) High voltage test

8.4 Test of refrigerating unit

8.4.1 Tightness test: The test is to be carried out with the electronic or helium leak detector under the pressure maintained for at least 24 h to ensure adequate tightness of the unit during the service cycle.

8.4.2 Vacuum test: The test is to be performed after success of the tightness test, with duration of no less than 2 h.

8.4.3 Insulation resistance test.

8.4.4 High voltage test (electrical).

8.4.5 Operation test: Refrigerating capacity is to be measured with the unit in continuous operation under the nominal condition.

8.4.6 Test of safety protection and alarm functions.