Guideline No.M-05(201510)

M-05

AIR COMPRESSOR

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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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AIR COMPRESSOR

1 Application

1.1 This Guideline applies to the type approval and inspection of marine air compressors for start-up of main and auxiliary machinery and other purposes (e.g. control and miscellaneous purposes).

1.2 The marine air compressors in this Guideline include piston air compressor and screw air compressor. For the air compressors of other constructions and types, refer to the requirements of this Guideline for approval and inspection.

2 Basis for approval and inspection

2.1 *CCS Rules for Classification of Sea-Going Steel Ships;*

2.2 *CCS Rules for Materials and Welding*

2.3 International/national/professional standards as below

ISO 5388 *Stationary Air Compressors - Safety Rules and Code of Practice*

3 Definitions

3.1 Rated condition: the working condition of air compressor jointly determined by the rated speed and the rated discharge pressure.

3.2 Volume flow: the air volume measured within unit time at the air outlet of air compressor operating under the rated condition and converted under the temperature and pressure of air aspirated before the first-stage air inlet.

3.3 Nominal volume flow: the air volume converted from the volume flow under the standard inlet condition and nominal speed.

3.4 Standard inlet condition: the condition of the aspirated air at the standard inlet position of the compressor where the inlet air temperature is 20℃, the pressure is the standard atmospheric pressure (0.101 MPa), the relative humidity is 0 and the cooling water inlet temperature is 15℃.

4 Plans and documents

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

(1) Main product performance specification table

(2) General assembly plan

(3) Plans of main parts and components, including the cylinder, end cover, connecting rod, crankshaft, compressor body and safety valve (where applicable) for piston air compressor, and the rotor, compressor body, air suction and discharge end covers, increasing gear, synchromesh gear (if any) and safety valve (where applicable) for screw air compressor.

(4) Oil-air separator

(5) Air receiver attached with the compressor (if any)

(6) List of physicochemical properties of main parts materials

(7) Schematic diagrams of automatic control device and safety alarm device

(8) Schematic diagrams of cooling system and lubricating system

(9) Calculation books (safety valve flow calculation, calculation of air receiver attached with the compressor, etc.)

(10) Type test program (submitted in case of application for type approval)

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

(1) Templates of product nameplate and certificate of inspection

(2) Product instructions

(3) Factory profile: Name, address, production history, capacity, technicians and inspectors, main products, affiliation, trademark, etc.

(4) Details of the product to be approved

(5) Main production equipment

(6) Main testing equipment

(7) A brief description on production technology of the product to be approved

(8) Quality management document

(9) Registration certificate

(10) Qualification certificate and/or production license

(11) Template of product quality certificate

(12) Quality control plan (where applicable)

5 Materials and components

5.1 The materials and components of the product are to be controlled according to relevant requirements of the CCS Rules currently in effect

5.2 The materials of main parts and components of air compressor are generally to comply with the applicable requirements of *CCS Rules for Materials and Welding*. If materials unspecified in the CCS Rules are used, the documents regarding the chemical composition, mechanical properties, heat treatment procedures, etc. of the materials are to be submitted to CCS for approval. Acceptance inspection may be performed according to relevant recognized standards with the consent of CCS.

6 Welding procedures qualification

The welding procedures for the air compressor body of a welding structure are to be subjected to the welding procedures qualification according to relevant requirements of Part Three of *CCS Rules for Materials and Welding*.

7 Design and technical requirements

7.1 Piston air compressor

7.1.1 The air compressor is to be fitted with a pressure gauge which may have the functions of watertightness, shock resistance and backlight as required.

7.1.2 A safety valve is to be set after each stage of compression. The set pressure of the inter-stage safety valve is not to be more than 1.2 times the maximum working pressure of the stage. The set pressure of the safety valve at the final stage is not to be more than 1.1 times the rated discharge pressure.

7.1.3 A safety valve is to be set when the volume of the crankcase of air compressor exceeds 0.6 m^3. The total flow area of the safety valve is to be more than 0.07 times the volume of crankcase.

7.1.4 In the cooling system of water-cooled air compressor, anti-rust and anti-corrosion measures are to be taken for the components contacting cooling water and a cooling water drainage channel is to be provided for cylinder water drainage.

7.1.5 The water-cooled air compressor is to be fitted with coolers. The multi-stage water-cooled air compressor is to be fitted with an intermediate cooler and an after-cooler. A cooling water safety valve or bursting disc and a drain cock or valve is to be fitted to the cooler. The outlet of the after-cooler of air compressor is to be fitted with a small fusible plug or alarm device which is to be fused or give an alarm when the air temperature exceeds 121 ℃ under the working pressure.

7.1.6 The air compressor is to be fitted with unloading mechanism. In the mode of automatic control, it is to be manually operated.

7.1.7 The air compressor is to be fitted with a liquid-air separator (the air-cooled air compressor with a nominal volume flow of not more than 24 m^3/h may not be fitted).

7.1.8 The air suction port of air compressor is to be fitted with an air filter.

7.1.9 The exposed moving parts of air compressor are to be provided with a shield mainly made of metal wire meshes or steel plates.

7.1.10 For the high-temperature exhaust pipe of air compressor, a thermal baffle or other appropriate heat insulation measures are to be taken to ensure the temperature of possible human contact part does not exceed 60 ℃.

7.1.11 The air compressor may have the following automatic control functions with automatic control devices sensitive and reliable:

(1) Automatic start/stop

(2) Automatic unloading

(3) Automatic discharge

(4) Monitoring of air, oil and water pressure

(5) Monitoring of air, oil and water temperature

7.1.12 The exhaust air temperature of every stage of air compressor at the rated discharge pressure is to be not more than 200℃. The temperature of the air into the air receiver is not to exceed the water inlet temperature plus 30℃ for the water-cooled air compressor, and not to exceed the ambient temperature plus 40℃ for the air-cooled air compressor.

7.1.13 The temperature of lubricating oil in the crankcase of air compressor is not to exceed 70℃ for the water-cooled air compressor, and not to exceed 80℃ for the air-cooled air compressor.

7.1.14 When the air compressor operates under the rated condition, for medium and low pressure air compressors (rated discharge pressure ≤ 4.0 MPa), the vibration intensity is not to be more than 18 mm/s; for high pressure air compressors (rated discharge pressure ≥ 15 MPa), the vibration intensity is not to be more than 28 mm/s; for the air compressor with a rated discharge pressure between 4 ~ 15 MPa, the vibration intensity is not to be more than 25 mm/s.

7.1.15 The parts under air pressure (e.g. cylinder, piston, cylinder liner, cooler, liquid-air separator, air pipe, etc.) are to be able to be subjected to hydrostatic tests under a pressure 1.5 times the maximum working pressure. The hydrostatic test pressure of water channel and water chamber is to be generally 0.50 MPa. The connections between parts under air pressure are not allowed to have leakage under the maximum working pressure.

7.2 Screw air compressor

7.2.1 The air compressor is to be fitted with a pressure gauge. The pressure gauge may have the function of water resistance or backlight as required.

7.2.2 A sensitive and reliable safety valve is to be set after each stage of compression of air compressor. The set pressure of inter-stage safety valve is not to be more than 1.2 times the maximum working pressure of the stage. The set pressure of safety valve at the final stage is not to be more than 1.1 times the rated discharge pressure.

7.2.3 The air compressor is to be fitted with an automatic flow control device so as to meet the requirements of the users on flow variation.

7.2.4 The air suction port of air compressor is to be fitted with an air filter.

7.2.5 An oil-air separator is to be set at the exhaust side of air compressor.

7.2.6 The pressure-bearing parts such as the housing, exhaust end cover, exhaust chamber and oil pump housing of air compressor are to be subjected to hydrostatic tests under a pressure 1.5 times the maximum working pressure.

7.2.7 The speed-increasing gearbox of air compressor, if any, is to be subjected to a kerosene leakage test.

7.2.8 The rotor of air compressor is to be subjected to a dynamic balance test.

7.2.9 The vibration intensity of air compressor is not to be more than 7.1 mm/s.

7.2.10 For the high-temperature exhaust pipe of air compressor, a thermal baffle or other appropriate heat insulation measures are to be taken to ensure the temperature of possible human contact part does not exceed 60 ℃.

7.2.11 The air compressor may have the following automatic control functions with automatic control devices sensitive and reliable:

(1) Automatic start/stop

(2) Automatic unloading

(3) Automatic discharge

(4) Monitoring of air, oil and water pressure

(5) Monitoring of air, oil and water temperature

8 Type test

8.1 Selection of typical sample

The test sample for test approval is to be representative of the processing capability and manufacturing level of the works and selected respectively according to the cooling means of the series of products applying for approval and the maximum nominal volume flow under the rated discharge pressure.

8.2 Type test items are to include:

Type test items **Table 8.2**

No.	Inspection item
1	Visual inspection
2	Test of main parts materials For the piston air compressor, including the cylinder, end cover, connecting rod, crankshaft and body. For the screw air compressor, including the rotor, body, air suction and discharge end covers, increasing gear and synchromesh gear (if any).
3	Pressure and tightness tests of main pressure-bearing parts
4	Dynamic balance test of rotor (applicable to screw air compressor)
5	Adjustment test and safety valve test
6	Test of automatic control and safety alarm device
7	Measurement of volume flow

Continued Table 8.2

8	Measurement of shaft power	
9	Measurement of vibration	
10	Durability test	
11	Environment adaptation test	Sway test
		Inclination test
		High-temperature and high-humidity test

Note: When the test item 7-11 in the table is performed, the temperature and pressure of air, water and oil are to be recorded and are not to exceed the values specified in the product technical specifications.

8.3 Type test methods and requirements

8.3.1 Visual inspection

The outside casting and welding surfaces of air compressor are to be cleaned completely without rust, stain or welding slag. The painting surface is to be flat and smooth with uniform color. The paint is to be able to protect against corrosion of salt mist and condensation. The shields of exposed moving parts are to be secure and stable. The heat insulation measures for exhaust pipes under high temperature are to be effective.

8.3.2 Test of main parts materials

For the main parts of air compressor such as crankshaft, connecting rod, rotor, body and gear, at least 2 ~ 3 parts are to be selected for the raw material test in order to verify the parts meet the specified requirements of plans and technical documents.

8.3.3 Pressure and tightness tests of main pressure-bearing parts

The parts under air pressure (e.g. cylinder, piston, cylinder liner, cooler, air-liquid separator, air pipe, housing, exhaust end cover, exhaust chamber, oil pump housing, etc.) are to be able to be subjected to hydrostatic tests to a pressure 1.5 times the maximum working pressure. The hydrostatic test pressure of water channel and water chamber is to be generally 0.50 MPa. The test is to last for 30 min. No leakage is to be allowed during the test.

The connections between parts under air pressure are to be subjected to tightness tests under the maximum working pressure. The test is to last for 10 min. No leakage is to be allowed during the test.

8.3.4 Dynamic balance test of rotor of screw air compressor

The rotor of air compressor is to be subjected to a dynamic balance test. The permissible offset per unit mass of rotor is to meet the specified requirements of approved plans.

8.3.5 Adjustment test and safety valve test

Each air compressor may be subjected to an adjustment test after the running-in period. The air compressor is to operate under the rated condition during the adjustment test. The vibration, air, cooling water and lubricating oil are to be checked for leakage or other abnormalities. The test is to last for at least 30 min. The temperature and pressure of air, water and oil are to be recorded.

The outlet shut-off valve is to be adjusted to make the pressure of air compressor steadily rise. Then the safety valve of air compressor is to be adjusted one by one (the inter-stage safety valve may be adjusted at the final stage) to make the safety valve open at the set pressure. The number of adjustment is not to be less than three times. The result is to be in accordance with the following provisions: The set pressure of inter-stage safety valve is not to be more than 1.2 times the maximum working pressure of the stage. The set pressure of safety valve at final stage is not to be more than 1.1 times the rated discharge pressure.

8.3.6 Test of automatic control and safety alarm device

Automatic control and safety alarm devices of air compressor are to be tested item by item according to the provisions of approved technical documents. The safety alarm device may be tested by simulation.

8.3.7 Measurement of volume flow

(1) Generally, the volume flow is to be measured with such measuring devices as “ISA1932 nozzle and deflector”, “ASME nozzle” or “Arc Venturi nozzle”. When those measuring methods are not appropriate, the “tank-filling method”, “bottle-weighing method” and “flow meter measuring method” may be used with the consent of the Surveyor.

(2) The volume flow measured is not to be lower than 95% of the nominal volume flow when the air compressor operates under the rated condition.

8.3.8 Measurement of shaft power

The shaft power of air compressor may be measured by the following methods:

(1) Directly measure the input torque and speed of compressor shaft with a tacho-torquemeter or a DC dynamometer;

(2) Measure the output power of motor with a calibrated direct-current motor, and then multiply the output power by the transmission efficiency;

(3) Indirectly measure the output power of motor by the loss analysis method, and then multiply the output power by the transmission efficiency;

(4) The measured value of the shaft power of air compressor is to be less than the specified numerical value.

8.3.9 Measurement of vibration

The vibration is to be measured when the air compressor operates under the rated condition. The vibration intensity is to meet the requirements of this Guideline. For the piston air compressor, the vibration measuring points are crankshaft and end cover of each stage. For the screw air compressor, the vibration measuring points are spindle and front and rear bearing blocks. Each

measuring point is to be respectively measured in three directions.

8.3.10 Durability test

(1) The air compressor applying for approval to CCS is to be subjected to a durability test according to the specifications of the table below:

Durability test **Table 8.3.10**

Sample type	Volume flow > 50 m^3/h		Volume flow ≤ 50 m^3/h	
	Accumulated running time	Number of starts	Accumulated running time	Number of starts
New design	1000	150	500	100
Significant modification of design or process	500	75	250	50

(2) The test is to be conducted under the rated condition. The volume flow of air compressor is to be measured when the test starts and ends. The flow is not to be reduced by more than 10%. The temperature and pressure of oil and water are to be measured every 10 h.

(3) The air compressor is to be subjected to teardown inspection after the test. All parts are to meet the specified requirements.

8.3.11 Environment adaptation test

The air compressor applying for approval to CCS is to be subjected to the tests below:

Environment adaptation test **Table 8.3.11**

Test item		Requirement	Running time	Inspection item
Sway test	Rolling	±22.5 °	> 0.5 h	Shaft power, lubricating oil pressure, cooling water pressure, air pressure of each stage, cooling water consumption
	Pitching	±7.5 °		
Inclination test	Heeling	±15 °	> 0.5 h	Shaft power, pressure and temperature of lubricating oil, pressure and temperature of cooling water, air pressure of each stage and air intake/exhaust temperature, cooling water consumption, volume flow
	Trimming	±5 °		
High-temperature and high-humidity test		Ambient temperature: 45 ℃; relative humidity: 95%; sea water: 32 ℃; fresh water: 40 ℃	> 4 h	Shaft power, pressure and temperature of lubricating oil, pressure and temperature of cooling water, air pressure of each stage and air intake/exhaust temperature, cooling water consumption, volume flow

8.4 Determination and exemption of the test items

All applicable test items in Article 8.3 are to be generally performed for the first approval. The applicant may apply for exemption of partial test items in written form provided that the following conditions are met. Considerations are to be paid by CCS according to the production status,

production history and usage records of products, etc.

(1) The applicant is able to provide the test report of appropriate test items issued by a recognized technical authority in recent period (within a year);

(2) The applicant is able to provide the test reports of appropriate test items signed by IACS members.

9 Unit/batch inspection

9.1 After obtaining type approval from CCS, the marine air compressor produced by the works in accordance with the approved conditions (including assembly, process, etc.) may be installed on board after passing the unit/batch inspection by CCS.

9.2 For approved products, the manufacturing works is to test each product according to items 1 ~ 8 listed in Table 9.2 and to submit a test report to the Surveyor of CCS for review. The Surveyor is to randomly take samples at a proportion of 10% for each specification of products applying for inspection. A certificate is to be issued once the product passes the inspection.

Factory test items **Table 9.2**

No.	Inspection items	Inspection method
1	Visual inspection	W
2	Test of main parts materials For the piston air compressor, including the cylinder, end cover, connecting rod, crankshaft and body. For the screw air compressor, including the rotor, body, air suction and discharge end covers, increasing gear and synchromesh gear (if any).	R
3	Pressure and tightness tests of main pressure-bearing parts	R
4	Dynamic balance test of rotor (applicable to screw air compressor)	R
5	Adjustment test and safety valve test	W
6	Test of automatic control and safety alarm device	W
7	Measurement of volume flow	W
8	Measurement of shaft power	W

Note: 1. “W” stands for onsite witness, while “R” stands for report review.