Guideline No. Z-09(202502)

Z-09

Marine Wind-Rotor Assisted Propulsion System

Issued date: February 1, 2025

Foreword

China Classification Society (hereinafter referred to as 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 service@ccs.org.cn .

Historical version and release date: newly edited

Main change: None

Contents

Marine Wind-Rotor Assisted Propulsion System

1 Application

1.1 The Guidelines are applicable to marine wind-rotor assisted propulsion systems.

1.2 The use of materials other than fibre-reinforced plastics for the construction of rotor shall be subject to special approval by the CCS.

1.3 Other generally-recognized standards may be accepted by CCS for the technical requirements and test methods mentioned in the Guidelines.

2 Normative references

(1) CCS Rules for Classification of Sea-going Steel Ships

(2) CCS Rules for Materials and Welding

(3) CCS Guidelines for Survey of Marine Wind-rotor Assisted Propulsion System

(4) CCS Guidelines for Type Approval Test of Electric and Electronic Products

(5) CCS Rules for Lifting Appliances of Ships and Offshore Installations

(6) CCS Rules for the Construction of Fiber-reinforced Plastic Ships

(7) CCS Guidelines for Survey of Fibre Reinforced Plastic Ships

(8) CCS Rules for Green Eco-ships

(9) CCS Guidelines for Evaluation and Survey of Marine Rigid Wing Sails

3 Terms and definitions

The terms and definitions defined in the above survey basis are applicable to the Guidelines. For the convenience of preparation and use, the following definitions are

directly quoted or supplemented in the Guidelines.

Marine wind-rotor assisted propulsion system: a wind energy utilization technology product that makes use of the Magnus effect to transfer the force generated by the rotation of the rotor to the hull to generate thrust to assist ship propulsion, thereby reducing the energy consumption of the propulsion system.

Rotor: the external cylindrical structure in the marine wind-rotor assisted propulsion system arranged on the weather deck of a ship. It is directly affected by wind force and driven to rotate by external forces, and transfers the generated thrust to the internal tower in the marine wind-rotor assisted propulsion system.

Internal tower and foundation: the internal structures of the marine wind-rotor assisted propulsion system, which support the installation, inspection and maintenance of the rotor and the driving system, and transfer the force generated by the rotor to the hull of the ship.

Driving system: the mechanism that drives the rotor to rotate.

Control, monitoring and alarm system: the system that realizes the functions such as rotor rotation speed and direction control, system status monitoring and safety protection.

4 Drawings and documents

4.1 During product drawing approval, the following drawings and data shall be submitted to CCS for approval:

(1) List of product main performance specifications of the system (including product model and specification, rotor material, rotor diameter, top cover diameter, inner tower diameter, rotor height, foundation height, maximum height, maximum design speed, motor rated power, self-weight, maximum continuous thrust, maximum resultant force of the system on the foundation, maximum torque of the system on the foundation, maximum ZH (vertical distance from the rotor centroid to the design waterline) applicable to the system, operating temperature, maximum operating wind speed and safe wind speed);

(2) Layout of system;

(3) Structural drawing of rotor;

(4) Structural drawing of internal tower (including main structure, rotor support structure, rotor connecting plate and locking structure);

(5) Structural drawing of foundation (excluding the reinforcing part of hull structure);

(6) Layout of rotation limiting device;

(7) Layout of locking device;

(8) Layout of driving device and system: layout of motor and gear box (for electric driving device); layout of hydraulic motor, drawing of hydraulic pipeline system (for hydraulic driving device);

(9) Layout of transmission device and system;

(10) Schematic diagram and layout of relevant systems of electrical equipment;

(11) Schematic diagram and layout of control, monitoring and alarm systems;

(12) Layout of ventilation system

(13) Layout of lighting system;

(14) Schematic diagram and layout of hydraulic system for foldable rotor;

(15) Other drawings deemed necessary by CCS.

4.2 During product drawing approval, the following drawings and data shall be submitted to CCS for approval:

(1) List of drawings to be submitted for approval;

(2) System design specifications, which shall at least include system overview, environment and capacity parameters, design parameters, functions of main components, system principles, system control functions and description of system external interfaces;

(3) List of main parts and components of the system and equipment specification table;

(4) System operation and maintenance instructions;

(5) Calculations of structural strength of rotor;

(6) Calculation of structure strength of internal tower and foundation;

(7) Material test report of rotor (if applicable);

(8) Aerodynamic force calculation report of rotor (if applicable);

(9) Model wind tunnel test report (if applicable);

(10) FMEA analysis (if applicable);

(11) Other drawings deemed necessary by CCS.

4.3 Precautions for Product Drawing Approval:

(1) The drawings of the reinforced part of the foundation-hull structure shall meet the requirements for ship drawing approval;

(2) Suggestions on the selection of ship loads and parameters in product drawing approval are as follows:

① In the calculation of system structure, the inertia force load caused by ship motion can be selected under the following conditions: longitudinal acceleration at ±0.5g; lateral acceleration at ±1.4g; vertical acceleration at ±1.2g;

② To simplify the green sea load, the design pressure of the outer wall of the rotor can be selected with a water head of 4m;

③ The system designer shall fully consider the types of ships on which the system may be installed and give an appropriate ZH (vertical distance from the rotor centroid to the design waterline) for calculation;

④ If the ship to which the system will be installed is defined, load parameters can also be determined according to the situation of the ship.

⑤ Other loads shall be selected and combined according to the CCS *Guidelines for Survey of Marine Wind-rotor Assisted Propulsion System.*

4.4 During approval, the following drawings and data shall be submitted for approval:

(1) Factory overview: factory name, address, production history, production capacity, technical and inspection personnel, main products, affiliation, product trademarks, etc.;

(2) Details of the product to be approved;

(3) List of main production equipment;

(4) List of main testing equipment;

(5) Brief production process of the product applied for approval, main process documents, welding procedure, joint connection process, layer lay-up design of relevant composite materials, connection process of rotor and components (including connection between rotor bodies, connection of rotor to stiffener and end flange);

(6) Quality management documents or quality system certificates;

(7) Enterprise registration certificate;

(8) Qualification certificate and/or production license, if applicable;

(9) Product quality certificate or sample of certificate;

(10) Quality control plan, if applicable;

(11) List of qualified suppliers, if applicable;

(12) Type test program.

5 Technical requirements

5.1 System design requirements

5.1.1 The layout and design of the system shall meet the requirements in CCS *Rules for Classification of Sea-Going Steel Ships, CCS Rules for Materials and Welding* and *CCS Guidelines for Survey of Marine Wind-rotor Assisted Propulsion System*. The following factors shall be considered: voyage sight line, navigation light, tonnage, fire safety, railing and handrail, radar system, maneuverability, explosion prevention, lightning protection, as well as the influence on total longitudinal strength, local strength, stability and electrical installations.

5.1.2 The enclosure protection level of electrical equipment in the system shall be suitable for the installation location.

5.2 Requirements for rotor

5.2.1 The key non-metallic raw materials used for manufacturing the rotor, such as fiber-reinforced plastic, resin and core layer material, shall meet requirements in Chapter 2 of Part 2 of CCS *Rules for Materials and Welding.* The operating temperature of the rotor shall be considered in the selection of resin and other materials, and the heat deformation temperature or glass transition temperature shall be at least 20°C higher than the maximum operating temperature of the rotor.

5.2.2 Each part of the rotor shall be manufactured by appropriate composite material molding process according to the structural characteristics, such as winding molding method, vacuum perfusion method, vacuum bagging molding method and manual laying method. For manufacturing processes such as production conditions, resin solution formulation, curing and demoulding, see requirements of Chapter 3, Part 2 of CCS *Rules for Materials and Welding*.

5.2.3 Adhesives for structures used in the manufacture of rotors shall meet the requirements of Chapter 3, Part 2 of CCS *Rules for Materials and Welding*. The

segments rotor shall not be bound by structural adhesive only.

5.2.4 The surface of the rotor shall be covered with coating of good moisture resistance, ultraviolet radiation resistance, marine climate resistance and low water absorption. In addition, the coating shall have good adhesion and compatibility with the rotor body material.

5.3 Requirements for internal tower and foundation

5.3.1 The design and structural calculation of the internal tower and foundation shall meet the requirements in Chapter 3 of CCS *Guidelines for Survey of Marine Wind-rotor Assisted Propulsion System*.

5.3.2 The materials and welding of the internal tower and foundation shall meet the requirements of the *Rules for Materials and Welding* and Chapter 6 of the *Rules for Lifting Appliances of Ships and Offshore Installations* of CCS.

5.4 Requirements for control, monitoring and alarm system

5.4.1 The control, monitoring and alarm system shall meet the requirements in Chapter 4 of the *Guidelines for Survey of Marine Wind-rotor Assisted Propulsion System* and Chapter 2, Part 7 of the *Rules for Classification of Sea-Going Steel Ships* of CCS.

5.4.2 The environmental test and electromagnetic compatibility test of the control, monitoring and alarm system shall be carried out according to requirements in GD019-2024 *Guidelines for Type Approval Test of Electric and Electronic Products* of CCS and IACS UR E10.

5.5 Requirements for arrangement in hazardous areas

5.5.1 The electrical equipment in the system shall not be arranged in hazardous areas as far as possible. If it is unavoidable, the actual hazardous area where the product locates shall be determined according to the division requirements of hazardous areas corresponding to different ship types, so as to judge the explosion-proof requirements that the equipment in the system shall meet. Electrical equipment to be located in a hazardous area shall have an explosion-proof certificate accepted by CCS;

5.5.2 The mechanical moving parts in the system shall be arranged in a non-hazardous area as far as possible. If it is unavoidable, for oil tankers, it shall be ensured that no sparks are generated during operation and the surface temperature of such parts does not exceed 200°C. For chemical or dangerous goods ships, the surface temperature of such parts shall not exceed the temperatures specified in applicable requirements for the chemicals or dangerous goods intended to be carried.

6 Materials and components

6.1 The marine wind-rotor assisted propulsion system mainly consists of the following parts: rotor, internal tower, driving system, monitoring, alarm and control system, foundation and other components.

6.2 Certification Requirements for Materials and Components

(1) The following components and materials shall be provided with the marine product certificates issued by CCS:

Rotor (if purchased), internal tower and foundation (if purchased), control, monitoring and alarm system (if purchased), gearbox, motor (50kW and above), hydraulic power unit, hydraulic motor/hydraulic cylinder, accumulator, frequency converter (50kW and above), frequency conversion control cabinet, communication cable, power cable and optical cable, fan (if used in hazardous area) and slewing bearing (if any).

(2) The following components and materials shall be provided with the approval certificates issued by CCS:

Aerovane, motor (below 50kW), frequency converter (below 50kW) and sensor.

(3) The following components and materials shall be provided with quality certificates:

Center shaft, limit support device, rotor locking mechanism, braking resistor, inclination meter, rotor locking limit switch, connecting plate bolt and locating pin.

6.3 The materials and components included in the list of qualified suppliers shall not be changed without the approval of CCS.

7 Type test

7.1 Selection of typical samples

The prototype selected for type approval shall be a representative product that can represent or cover the product or series of products applying for type approval in terms of characteristics, features and manufacturing quality.

Products made of different rotary drum materials and manufactured with different rotary drum processes should be selected separately for the relevant type tests in section 7.2 (2).

7.2 Type test items

The type test items of marine wind-rotor assisted propulsion system shall include:

(1) Verification of certificates and quality certificates for main materials, parts and components;

(2) Manufacture and survey of rotor;

(3) Manufacturing and survey of internal tower and foundation;

(4) Survey of control, monitoring and alarm system;

(5) Wind tunnel test (if applicable);

(6) Verification of requirements for layout in hazardous areas (if applicable);

(7) System integration test.

7.3 Test requirements and test methods

For test requirements and test methods, please refer to the following requirements:

7.3.1 Verification of certificates and quality certificates for main raw materials,

parts and components

The manufacturer shall submit the certificates and quality certificates of main raw materials, parts and components to CCS for verification according to 6.2.

7.3.2 Manufacture and survey of rotor

(1) Molding procedure qualification

The necessary forming procedure shall be developed and submitted to CCS for review prior to manufacturing of the rotor. For the forming procedure, refer to the requirements in Chapter 3, Part 2 of CCS Rules for Materials and Welding. Specimens of laminate and/or sandwich panels shall be prepared as per the procedures for forming process approval tests.

The specimen shall be in such thickness as to represent the thinnest part of the rotor. Test items such as density, Barcol hardness, fiber content, tensile test, compression test, bending test, interlaminar shear strength and Poisson's ratio shall be checked in laminate specimen. Shear strength test of core material shall also be carried out for sandwich panel test panels in addition. See Table 7.3.2(1) for details.

The direction requirements shall be considered in the preparation of specimens, and the fiber direction and ply direction shall be strictly consistent with the test requirements. The test direction and test results shall meet the design requirements of rotor. When there are other clear performance requirements in the design of rotor, the specific design shall prevail.

Table 7.3.2(1) Test Items of Specimen

Test Items	Standard
Tensile strength (N/mm^2)	ISO 527-4
Tensile modulus (N/mm^2)	ISO 527-4
Poisson's ratio	IS0 527-4
Bending strength (N/mm^2)	ISO 14125
Flexural modulus (N/mm^2)	ISO 14125
Compression strength (N/mm^2)	ISO 604
Compression modulus (N/mm^2)	ISO 604
Interlaminar shear strength (N/mm^2)	ISO 14130
Fiber content (%, mass ratio)	ISO 1172 (fiberglass)

Test Items	Standard
	ASTM D3171 (carbon/aramid)
Barcol hardness	ASTM D2583
Density	ISO 1183-1
Shear strength of core material (sandwich panels only)	ISO 1922 or EN 1465 etc.

(2) Bonding procedure qualification

The procedures for bonding by adhesives for load-bearing parts are to be submitted to CCS for approval with evidence that the strength of bonding joints meets the design requirements (e.g. historical test records of the same bonding procedure). If a new bonding procedure is used, the strength of the bonding joint is to be verified by test to confirm that its strength and other properties meet the design requirements.

(3) Product molding test

During molding of the main rotor, a test panel for verification shall be laid up at the same time. The test panel shall be taken from the extension part of the rotor. If this is not impracticable, simulation fabrication shall be carried out under the same environmental conditions with the same raw materials, formulas and procedure (except for gel coat layer) as those for actual production. In the actual product survey, one molding test is acceptable for each batch of rotors produced in mass with the same drawing, procedure and conditions.

For laminate properties, the following items shall be tested, and the results of each property test shall not be lower than the design performance of the laminate.

① Fiber content (glass fiber: ISO1172; carbon fiber/aramid fiber: ASTM D3171);

② Tensile strength and modulus (ISO 527-4);

③ Bending strength and modulus (ISO 14125);

④ Compression strength and modulus (ISO 604);

⑤ Interlaminar shear strength (ISO 14130);

⑥ Shear strength of core material (ISO1922 or EN 1465).

(4) Appearance and dimension inspection

Rotors shall be manufactured according to drawings and documents and molding procedure approved by CCS. After manufacturing, appearance and dimension inspection shall be carried out.

The appearance of the product shall be free from defects such as openings, pores, grooves, cracks or fiber exposure that exceed the design requirements.

The dimension inspection of the product shall include the measurement of diameter, length, wall thickness, roundness, concentricity and straightness of the rotor, which shall meet the requirements of the drawings approved by CCS.

7.3.3 Manufacture and inspection of internal tower and foundation

(1) Before construction, the factory shall carry out welding procedure approval according to requirements of Chapter 3, Part 3 of CCS Rules for Materials and Welding. The welding procedure can only be used after being approved by CCS.

(2)The internal tower and foundation shall be constructed and manufactured according to the drawings approved by CCS. After manufacturing, appearance inspection, dimension inspection and NDT shall be carried out;

(3) Welding inspection:

All weld surfaces shall be visually inspected.

For quenched and tempered steel with yield strength greater than or equal to 420 N/mm^2, NDT of welds shall be carried out 48 hours after welding. NDTs shall be carried out after heat treatment if required.

Refer to Table 7.3.3(3) for the type and scope of NDT of welded structures.

Table 7.3.3(3) Scope of NDT for Welded Structures (%)

Position of Weld	Joint type	Visual inspection	Testing Method		
			RT	UT	MT
Circumferential welds in foundation and supporting components; transition components between foundation and supporting structure	Butt joint	100	10~20	100	100
	Cross/T-shaped joint, full penetration	100	-	100	100
	Cross/T-shaped joint, fillet/deep penetration welding	100	-	-	100
Important welds of supporting components and components generating thrust	Butt joint	100	5~10	50~80	20~50
	Cross/T-shaped joint, full penetration	100	-	50~80	20~50
	Cross/T-shaped joint, fillet/deep penetration welding	100	-	-	20~50
Other welds	Butt joint	100	-	2~5	2~5
	Cross/T-shaped joint, full penetration	100	-	2~5	2~5
	Cross/T-shaped joint, fillet/deep penetration welding	100	-	-	2~5

7.3.4 Inspection of control, monitoring and alarm system

(1) The control, monitoring and alarm system shall be subject to the following environmental test and electromagnetic compatibility test according to GD019-2024 Guidelines for Type Approval Test of Electric and Electronic Products of CCS and relevant provisions of IACS UR E10, as shown in Table 7.3.4(1).

Table 7.3.4 (1) Items for Environmental Test and Electromagnetic Compatibility Test

S/N	Test Items	Test requirements and test methods
Environmental test		
1	Visual inspection	Clause 2.1 of GD019-2024
2	Performance and temperature rise test	Clause 2.2 of GD019-2024 and GB/T3797
3	Insulation resistance measurement	Clause 2.3 of GD019-2024
4	Power supply vibrations test	Clause 2.4 of GD019-2024
5	Power supply failure test	Clause 2.5 of GD019-2024
6	Vibration test	Clause 2.7 of GD019-2024
7	Dry heat test	Clause 2.8 of GD019-2024
8	Cold test	Clause 2.9 of GD019-2024
9	Damp heat test(cyclic)	Clause 2.10 of GD019-2024
10	Salt mist test (if applicable)	Clause 2.12 of GD019-2024
11	Withstand voltage test	Clause 2.14 of GD019-2024
12	Enclosure protection test	Clause 2.15 of GD019-2024
13	Flame retardant test (if applicable)	Clause 2.16 of GD019-2024
Electromagnetic compatibility test		
1	Conducted emission test	Clause 3.2 of GD019-2024
2	Radiated emission test	Clause 3.3 of GD019-2024
3	Electrostatic discharge test	Clause 3.4 of GD019-2024
4	Electromagnetic field test	Clause 3.5 of GD019-2024
5	Electrical fast transient/burst test	Clause 3.6 of GD019-2024
6	Surge test	Clause 3.7 of GD019-2024
7	Conducted low Frequency test	Clause 3.8 of GD019-2024
8	Conducted Radio Frequency test	Clause 3.9 of GD019-2024

(2) The control and monitoring and alarm system shall have the following functions, which shall be verified by tests.

① The system shall have monitoring and automatic and manual control

functions, so as to keep the system operation within the predetermined parameter range under different operating conditions;

② The system shall be designed in such a way that one fault occurring during operation will not lead to other faults, and the risk caused by it shall be minimized;

③ When the system suffers a serious fault (such as motor overspeed and system out of control), it shall be able to give an alarm. Manual emergency stop devices independent of the control system shall be provided in the bridge and other remote control positions (if any) and in a local position, and so arranged that operation by mistake can be prevented.

④ The following displays shall be provided in the bridge and other control positions (if any):

Driving motor working conditions;

Voltage, current, frequency and power of driving motor;

Rotor rotating speed and direction;

Wind direction and speed (other than local position);

System control mode;

Status indication of the locking device.

⑤ The following audible and visual alarms shall be provided in the bridge and other control positions (if any):

Control, monitoring and alarm system fault;

Power supply fault of propulsion system;

Power supply fault of control, monitoring and alarm system;

Driving motor fault;

Switching of standby motor (if any);

Motor cooling medium (if any) temperature high;

Motor overspeed;

System emergency stop;

Pump boost voltage high (if applicable).

7.3.5 Wind tunnel test (if applicable)

(1) Test purpose

In order to measure the aerodynamic characteristics of the marine wind-rotor assisted propulsion system, the model wind tunnel test can be carried out on a single rotor to obtain the thrust coefficient, drag coefficient, power consumption, allowable angle-of-attack range and rotational speed range and provide reference for predicting the thrust matrix and power consumption matrix of the system.

The test results can be compared with the CFD calculation results to verify the aerodynamic characteristics of the rotor.

(2) Requirements for wind tunnel laboratory

The following information shall be submitted to CCS:

Description of facilities and equipment in the wind tunnel laboratory, including facility name, details of equipment and calibration records of each monitoring device; main facilities and equipment for wind tunnel test: large low-speed wind tunnel, strain box balance for ship aerodynamic force measurement, dynamic strain testing system for signal acquisition and processing of strain balance, and temperature, humidity and atmospheric pressure sensors for test environment measurement.

(3) Test conditions

① The model wind tunnel test shall meet the geometric similarity criterion, and the rotor model shall be scaled in equal proportion;

② The model wind tunnel test shall meet the dynamic similarity criterion, and the model size and wind tunnel speed shall match the Reynolds number;

③ In the wind tunnel test, the Reynolds number of the test shall be greater than 1.0×10^5. The Reynolds number, Re, is expressed by the following formula:

$$R_e = \frac{\rho \cdot U \cdot C}{\mu}$$

where ρ and μ are the density and viscosity of the chamber air, respectively, U is the model test wind speed, and C is the outer diameter of the marine wind-rotor assisted propulsion system.

④ The blockage ratio, calculated by dividing the transverse projected area of the model by the cross-sectional area of the wind tunnel test section, shall not exceed 5%.

⑤ The model can be made of steel or aluminum, and the machining accuracy and roughness shall meet the requirements of test procedures.

On the basis of meeting the above test conditions, both the Reynolds number of the test and the outer diameter of the rotor model shall be as large as possible.

(4) Test scheme

The test scheme shall indicate the dimensions of the wind tunnel laboratory, the maximum wind speed in the test section, the Reynolds number, the blockage ratio, the material, size and scaling ratio of the

model, the fixing method of the model, the parameters measured in the test and the measurement method, the detailed test procedure in detail and shall be submitted to CCS for approval.

(5) Processing of test results

① Calculate the thrust coefficient and resistance coefficient

The thrust coefficient of the model can be determined as: $C_{Fx} = Fx / (0.5\rho V^2 A)$

The drag coefficient of the model can be determined as: $C_D = F_D / (0.5\rho V^2 A)$,

where C_{Fx} is the thrust coefficient of the model, C_D is the drag coefficient of the model, Fx is the thrust generated by the model, F_D is the drag generated by the model,

ρ is the air density of the model, V is the wind speed of the model test, and A is the projected area of the marine wind-rotor assisted system.

② Draw the curve of thrust coefficient and drag coefficient changing with rotor speed and wind speed, and draw the power consumption curve to obtain the optimal attack angle range and rotating speed range of the system.

③ Compare with CFD calculation results and verify the aerodynamic characteristics of rotor.

7.3.6 Verification of requirements for layout in hazardous areas (if applicable)

If the system needs to be installed in a hazardous area of the ship, the explosion-proof certificate of relevant electrical equipment shall be submitted to CCS for verification, and the mechanical moving parts shall meet the requirements of 5.5.2 of the Guidelines.

7.3.7 System integration test

After the whole system is assembled, the following integration tests shall be

carried out:

(1) Automatic and manual control function test;

(2) Emergency stop function test;

(3) Locking device test;

(4) Display and alarm test of control, monitoring and alarm system;

(5) Verification of system control logic;

(6) If more than one control position is provided, the control shall be switchable between control positions;

(7) If the rotor is foldable, a utility test shall be carried out;

(8) Static and dynamic balance inspection: After the whole system is installed, static and dynamic balance inspections shall be carried out on the rotor, and the inspection results shall meet the design requirements.

8 Unit/batch inspection

8.1 Each set of marine wind-rotor assisted propulsion system shall be subject to single-piece/single-batch inspection and obtain the marine product certificate.

8.2 The unit/batch inspection approved by CCS shall be carried out according to the product inspection plan approved at the time of approval. Specifically, the following test items shall be included:

(1) Verification of certificates and quality certificates for main materials, parts and components;

(2) Verification of system composition;

(3) Inspection of rotor: including product molding test, appearance and dimension inspection;

(4) Appearance, dimension inspection and NDT of internal tower and foundation;

(5) Test of control, monitoring and alarm system: including insulation resistance measurement, voltage withstand test, alarm, safety function, control function test and software version inspection;

(6) Verification of requirements for layout in hazardous areas (if applicable);

(7) System integration test.

8.3 The test items for which the test reports should be submitted to CCS for review are as follows:

For all products to be surveyed, the reports of tests carried out as required in 8.2 above;

Verification certificate or verification list of test instruments and meters.