

Guideline No.M-15(201510)



M-15
WATER-JET PROPULSION
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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CONTENTS

1 Application4

2 Basis for approval and inspection.....4

3 Definitions4

4 Plans and documents4

5 Materials and components5

6 Welding procedures qualification.....5

7 Design and technical requirements.....5

8 Type test8

9 Unit/batch inspection.....11

WATER-JET PROPULSION PLANT

1 Application

1.1 This Guideline applies to the product inspection of water-jet propulsion plants for main propulsion of ships.

1.2 This Guideline applies to the overhanging type water-jet propulsion plant, i.e. the water-jet propulsion assembly, which is composed of water-jet propulsion pump (hereafter referred to as “pump”) and unit rudder. This Guideline may also be taken as a reference for built-in water-jet propulsion plants.

1.3 For specific requirements on the associated prime mover, gearbox, steering gear and hydraulic/electrical control device, refer to the *CCS Rules for Classification of Sea-going Steel Ships* and relevant requirements of this Guideline on associated products.

2 Basis for approval and inspection

2.1 The following standards are the bases for approval and inspection in this Guideline:

- (1) *CCS Rules for Classification of Sea-Going Steel Ships*;
- (2) *CCS Rules for Materials and Welding*;
- (3) *CCS Rules for Construction and Classification of Sea-Going High Speed Craft*

3 Definitions

3.1 For the purpose of this Guideline, the terms and definitions given in ISO 3715 and the *CCS Rules for Classification of Sea-going Steel Ships* apply.

4 Plans and documents

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

- (1) Main performance specifications of product (unnecessary to be individually submitted if included in the plans);
- (2) General assembly plan;
- (3) Plans of main parts and components (pump shaft assembly, layout of unit rudder, rudder and astern running control scoop, pump shaft, coupling, pump housing, impeller, diffuser, rudder stock, rudder bearing, rudder blade, rudder housing, rudder pintle, sealing device, etc.);
- (4) Schematic diagrams of main systems (lubricating oil, cooling, control systems) and safety alarm devices (refer to the plan approval requirements for relevant devices);

- (5) Calculation books (including shafting calculation book, rudder system calculation book, etc.)
- (6) List of physicochemical properties of main parts materials (unnecessary to be individually submitted if included in the plans);
- (7) Test program (where applicable).

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

- (1) Relevant main acceptance standards;
- (2) Product instructions.

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.

6 Welding procedures qualification

6.1 The welding procedures for welded components such as pump housing, diffuser, rudder blade and rudder housing of water-jet propulsion plant are to be subjected to the welding procedures qualification according to relevant requirements of *CCS Rules for Materials and Welding* before application.

7 Design and technical requirements

7.1 Marine environmental conditions

- (1) The water-jet propulsion plant is to be able to work normally at the following ship angles of inclination: heeling $\pm 15^\circ$, rolling $\pm 22.5^\circ$, trimming $\pm 5^\circ$ and pitching $\pm 7.5^\circ$.
- (2) The water-jet propulsion plant is to be so designed and arranged as to meet the ambient temperature conditions in 1.2.1.2, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.

7.2 Main materials and material tests

- (1) The materials of shafting and rudder systems of water-jet propulsion plant are to comply with the requirements of 11.1.2.2, Part Three of *CCS Rules for Classification of Sea-going Steel Ships* and the provisions of *CCS Rules for Materials and Welding*.
- (2) The water-jet propulsion plant and its main parts and associated parts are to be subjected to a non-destructive material test according to the *CCS Rules for Materials and Welding*.

7.3 Control and manipulation

- (1) The water-jet propulsion plant is to be generally controlled from the navigation bridge and locally, and a rudder angle indicator is to be fitted at such control positions.
- (2) See relevant provisions of 13.1.8.3, Part Three and Chapter 1, Part Four of *CCS Rules for Classification of Sea-going Steel Ships* for the requirements on rudder angle indicator.
- (3) If the water-jet propulsion plant has electric or electro-hydraulic power equipment of unit rudder or steering & reversing device, spare power equipment or other emergency control measures are to be provided. If there are two or more independent water-jet propulsion plants on the ship, spare power equipment is not necessary.
- (4) The time of rudder movement of water-jet propulsion plant is to be in accordance with (or equivalent to) relevant requirements of the ship Administration.
- (5) The device which can control the direction of water-jet propulsion plant of high speed craft is to comply with relevant provisions of Section 9, Chapter 6 of *CCS Rules for Construction and Classification of Sea-going High Speed Craft*.
- (6) The navigation bridge is to be fitted with devices indicating the pump speed and the position of the astern running control scoop of unit rudder. If there is a prime mover speed indicator in the navigation bridge, the pump speed indicator is not necessary.

7.4 Shaft calculation

- (1) Diameters of pump shaft and intermediate shaft of water-jet propulsion plant are not to be less than the values calculated by the formula in 11.2.2.1, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (2) For shafts where the bore is greater than 0.4 times the above-mentioned calculated value, the diameter of the shaft is to be corrected according to 11.2.3.1, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (3) The pump shaft of water-jet propulsion plant of high speed craft is to comply with relevant provisions of Article 6.7.2, Section 7, Chapter 6 of *CCS Rules for Construction and Classification of Sea-going High Speed Craft*.

7.5 Shafting vibration calculation

- (1) For the water-jet propulsion plant driven by a diesel engine, appropriate vibration calculation parameters are to be provided.
- (2) Shafting vibration calculation of ship power and propulsion systems including diesel engine and transmission is to comply with the provisions of Chapter 12, Part Three of *CCS Rules for Classification of Sea-going Steel Ships* and is to be submitted to the ship plan approval authority for review.

7.6 Couplings and connecting bolts

- (1) Flange couplings are to meet the requirements of 11.3.2.1, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (2) Couplings with the torque transmitted through a key are to meet the requirements of 11.3.2.2, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (3) Keyless couplings fitted by oil shrink method are to meet the requirements of 11.3.2.3, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (4) Clamp couplings are to meet the requirements of 11.3.2.4, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (5) Coupling bolts are to meet the requirements of 11.3.3, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (6) Test results or service experience information of the couplings of other types or with the torque transmitted by other means are to be provided to prove their reliability.

7.7 Impeller

- (1) The strength and installation of impeller are to comply with the provisions of Section 4, Chapter 11, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (2) The impeller is to be subjected to a non-destructive test according to the requirements of 8.4.3, Chapter 8, Part Three of *CCS Rules for Materials and Welding*.
- (3) The impeller is to be subjected to a static (or dynamic) balance test according to the plans approved.

7.8 Rudder system

- (1) The rudder stock is to comply with the provisions of 3.1.5, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.
- (2) The rudder blade is to comply with the provisions of 3.1.6, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.
- (3) The connection of rudder stock and rudder blade is to comply with the provisions of 3.1.7 ~ 3.1.10, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.
- (4) The rudder pintle is to comply with the provisions of 3.1.11, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.
- (5) The rudder bearing is to comply with the provisions of 3.1.13, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.
- (6) The rudder tiller is to comply with the provisions of 3.1.15, Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.

Rules for Classification of Sea-going Steel Ships.

7.9 Pump housing and diffuser

- (1) The pump housing and diffuser are to comply with relevant provisions of Chapter 3, Part Two of *CCS Rules for Classification of Sea-going Steel Ships*.

7.10 Hydraulic system

- (1) The hydraulic system is to comply with the requirements of 13.1.7, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*.
- (2) The hydraulic pipeline is to be subjected to a hydraulic test to a pressure of 1.5 times the working pressure. On completion of installation on board, the hydraulic pipeline along with its associated part is to be tested to 1.25 times the working pressure for tightness.

7.11 Lubricating system

- (1) Pumps lubricated with oil are to have an independent lubrication circuit.
- (2) Design-approved oil seals are to be installed to prevent sea water from entering the oil-lubricated parts of water-jet propulsion plant.

7.12 Bearing temperature

- (1) The temperature of the sliding bearing of water-jet propulsion plant is not to exceed 70 °C, and the temperature of the rolling bearing is not to exceed 80 °C.

7.13 Requirements for anticorrosion

- (1) Effective anti-corrosive measures are to be taken to prevent underwater components from being corroded by sea water.

8 Type test

8.1 Selection of typical sample

The first product of the same type is to be type-tested.

8.2 Type test items are to include:

- (1) Visual inspection;
- (2) Hydrostatic test;
- (3) Operation test (where applicable);

- (4) Pump performance test (where applicable);
- (5) Pump cavitation test (where applicable);
- (6) Pump mounting inclination test (where applicable);
- (7) Steering test.

The pump performance test may be replaced by the reduced-scale model test. The bench test only applies to small-power products.

8.3 Test bench and instrument

- (1) The arrangement of test bench is to be able to simulate the actual installation condition of the water-jet propulsion plant on board.
- (2) The measuring instrument is to have the metrological calibration certificate within the period of validity, with an accuracy of not less than that specified in Table 8.3:

Permissible system error of test instrument

Table 8.3

Item	Permissible range %
Pressure	±2.5
Flow	±2.5
Power	±2.0
Temperature	±2.0
Speed	±1.0

8.4 Type test methods and requirements

(1) Visual inspection

- ① The shafting and rudder systems of the product are to be subjected to visual, integration and safety inspections.
- ② The components of the product are to be complete with intact and undamaged appearance, sound protective layer and tight fasteners.

(2) Hydrostatic test

- ① Before the outer layer is welded, the pump housing is to be subjected to a hydrostatic test to a pressure of 1.5 times the maximum working pressure for at least 10 min. The surface

of the pump housing is to have no leakage or sweating during the test.

- ② On completion of fabrication, the rudder housing and blade are to be subjected to a hydrostatic test to a pressure of 0.2 MPa for at least 10 min. No leakage or sweating is to be present during the test.

(3) Operation test (where applicable)

- ① The water-jet pump and the unit rudder are to be subjected to an operation test on the test bench of the manufacturing works.
- ② The rotation speed is to be gradually increased to the rated speed. The test is to last for at least 2 h.
- ③ The bearing temperature and temperature rise during the test are to be measured, and the sealing condition is to be checked.
- ④ The system is to be able to work smoothly and steadily without abnormal noise; the temperature of sliding bearing is not to exceed 70 °C; and the amount of liquid leakage is not to exceed 7 mL/min during continuous operation.

(4) Pump performance test (where applicable)

- ① The water jet pump is to be subjected to the tests of flow, lift, power and efficiency under the rated condition.
- ② Clean water under normal temperature is allowed to be taken as the working medium.
- ③ The rotation speed is allowed to be reduced for real pump test.
- ④ More than 15 different flow points are to be taken as the measuring points of performance test and be uniformly distributed on the whole performance curve.
- ⑤ The temperature of the sliding bearing is not to exceed 70 °C, and the temperature of the rolling bearing is not to exceed 80 °C.
- ⑥ The water-jet pump is to be able to work smoothly and steadily without abnormal noise.

(5) Pump cavitation test (where applicable)

- ① The $(NPSH)_c$ at 50%, 100% and 120% the rated flow is to be respectively measured.
- ② The $(NPSH)_r$ is to be determined based on the $(NPSH)_c$ measured at 100% the rated flow.
- ③ The value obtained by the $(NPSH)_r$ minus the $(NPSH)_c$ is not to be less than 0.3 m.

(6) Pump mounting inclination test (where applicable)

- ① The test is to be carried out when the pump axis is at a trimming angle of $\pm 5^\circ$.
- ② The test is to be carried out at the rated flow for 1 h.
- ③ No damage affecting the normal use of pump parts is to be allowed after the test.

(7) Steering test

- ① The rudder housing and blade are to be turned from left full rudder to right full rudder for several times to conduct the no-load ahead steering test.
- ② The rudder housing is to be set at an angle of 0° and the rudder blade is to be turned to the left and right to make the rudder blade trailing edge closely fit the internal cavity of the rudder housing for the closing test of the rudder blade and housing.
- ③ The time of rudder movement, the angle of rudder blade and the steering pressure are to be measured during the test.
- ④ The system is to be able to work smoothly and steadily without abnormal noise. The clearances between the top and bottom sides of rudder blade and the rudder housing are to be even.

9 Unit/batch inspection

9.1 Inspection content

- (1) Inspections of water-jet propulsion plant are to include document examination and in-process inspections and performance tests.
- (2) In-process inspections are to mainly include material tests, hydrostatic tests, non-destructive tests of main parts, static (or dynamic) balance test of impeller, welding of parts, inspection of assembly quality, etc.
- (3) Main parts such as pump shaft, intermediate shaft, impeller, rudder stock, rudder pintle, coupling and connecting bolt (if any) are to be subjected to a mechanical property test.
- (4) The water-jet propulsion plant is classified according to the model and the maximum power. The first product is to be type-tested according to Article 8 of this Guideline. The subsequent products may be tested according to the unit/batch inspection items.

9.2 The reports or records required to be submitted by the manufacturing works are to at least include:

- (1) Quality assurance certificate and/or re-test report of physicochemical properties of materials

- of main product parts processed at the manufacturing works;
- (2) Certificate of conformity and relevant certificates of main purchased parts or outsourced parts;
 - (3) Inspection, measurement and test conditions of manufacturing works, a list of test and inspection equipment and copies of valid calibration certificates;
 - (4) Test report of manufacturing works, which is to include the model, specifications and serial number of product or sample, test place and date, test environment, test items and data, problems discovered during test and inspection and corresponding solutions, and test results.

9.3 In general, unit/batch inspection items are to include:

- (1) Visual inspection;
- (2) Hydrostatic test;
- (3) Operation test (where applicable);
- (4) Pump performance test (where applicable);
- (5) Steering test.

9.4 For the water-jet propulsion plant type-modified after type test, CCS may reduce relevant test items or test time during the inspection provided that its maximum power is not more than that of the prototype and its construction is similar to or main components are carried over from the prototype.