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M-17

Z PROPULSION ARRANGEMENT

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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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Z PROPULSION ARRANGEMENT

1 Application

1.1 This Guideline applies to the product inspection of Z propulsion arrangements (including Z/L-type azimuthing liftable outward-swaying rudder propeller) for main propulsion of ships.

1.2 Except this Guideline, the Z propulsion arrangement of controllable-pitch propeller type is to meet the applicable requirements in the guideline for the inspection of controllable-pitch propeller.

1.3 For specific requirements on the associated prime mover, hydraulic device, electrical control device and components, 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 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 (propeller, power shaft, vertical shaft, propeller shaft, bevel gear and shaft, upper/lower gearbox, stem tube, support tube, steering nozzle, etc.);

(4) Schematic diagrams of main systems (hydraulic and electrical control systems) and safety alarm devices (refer to the plan approval requirements for relevant devices);

(5) Calculation books (including shafting strength calculation book, propeller blade strength calculation book, etc.);

(6) List of physicochemical properties of main parts materials (unnecessary to be submitted if included in the plans);

(7) Test program (where applicable).

4.2 The following plans and documents are to be submitted for information depending on the situation:

(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 the foundation, support tube and steering nozzle of Z propulsion arrangement 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 Z propulsion arrangement is to be able to work normally at the following ship angles of inclination: heeling ±15°, rolling ±22.5°, trimming ±5° and pitching ±7.5°.

(2) The Z propulsion arrangement 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 Strengthening for navigation in ice

(1) For ships navigating in ice areas and granted relevant CCS class notations, their propulsion machinery and auxiliary equipment are to comply with the relevant provisions of Sections 1 ~ 3, Chapter 14, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

7.3 Main materials and material tests

(1) The materials of shafting system and propeller of Z propulsion arrangement 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 Z propulsion arrangement 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.*

7.4 Control and manipulation

(1) The Z propulsion arrangement is to be controlled from the navigation bridge, the machinery control position and the local position, 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 Z propulsion arrangement has electric or electro-hydraulic power equipment of

steering tuning device, spare power equipment or other emergency control measures are to be provided. If there are two or more independent Z propulsion arrangements on the ship, spare power equipment is not necessary.

(4) The time of rudder movement of Z propulsion arrangement is to be in accordance with (or equivalent to) relevant requirements of the ship Administration.

(5) The steering turning device of Z propulsion arrangement is to comply with relevant requirements of Section 1, Chapter 13, Part Three of CCS *Rules for Classification of Sea-going Steel Ships* on steering turning device.

7.5 Shaft calculation

(1) Diameters of input shaft, vertical shaft and propeller shaft of Z propulsion arrangement 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) For intermediate shafts and thrust shafts outside machinery of ships with ice notation B1*, the diameter of the shaft is to be increased by 10% based on the above-mentioned calculated value.

(4) The calculation of propeller shafts of ships with ice notations B1*, B1, B2 and B3 is to comply with the provisions of 14.2.2, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

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) The setting of universal couplings is to meet the requirements of 11.3.7.2, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

7.7 Shafting vibration calculation

(1) Shafting vibration calculation of Z propulsion arrangement 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.

7.8 Propeller

(1) The strength and installation of propeller 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 design of the propellers of ships with ice notations B1*, B1, B2 and B3 is to comply with the provisions of Section 3, Chapter 14, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

(3) The propeller is to be subjected to a non-destructive test and a static or dynamic (where applicable) balance test according to the requirements of 9.1.6.5 and 9.1.6.7, Chapter 9, Part One of CCS *Rules for Materials and Welding.*

7.9 Steering nozzle

(1) The steering nozzle is to comply with the provisions of Article 8, Section 1, Chapter 10, Part Ten of CCS *Rules for Classification of Sea-going Steel Ships.*

7.10 Transmission gearing

(1) The transmission gearing for Z propulsion arrangements with a transmitted power of equal to or more than 100 kW is to comply with the relevant provisions of Chapter 10, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

(2) The tightness test of the gearbox is to comply with the requirements of 11.3.7.8, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

7.11 Hydraulic system

(1) 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 design pressure. On completion of installation on board, the hydraulic pipeline along with its associated parts is to be tested to 1.25 times the design pressure for tightness.

7.12 Clutch

(1) The clutch is to comply with the requirements of 11.3.4, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

7.13 Bearing

(1) Sliding bearings and rolling bearings are to comply with the design working condition of Z-type propulsion arrangement. The design and type selection of rolling bearings may be conducted by the calculation method recommended by the bearing manufacturer.

(2) The temperature of the sliding bearing is not to exceed 70℃, and the temperature of the

rolling bearing is not to exceed 80℃.

7.14 Alarm

(1) All alarms associated with the system failure are to be indicated in the bridge.

(2) Alarm functions of Z propulsion arrangement are to include: low pressure of lubricating oil (if fitted with lubricating oil pump), high temperature of lubricating oil, low level of hydraulic oil, low pressure of hydraulic oil, high temperature of hydraulic oil (if fitted with oil cooler), too high pressure difference of hydraulic oil filter (if fitted with oil filter) and low pressure of clutch.

(3) Alarm requirements are to comply with relevant provisions of 13.1.9, Part Three and Section 2, Chapter 3, Part Seven of CCS *Rules for Classification of Sea-going Steel Ships.*

7.15 Sealing and anti-corrosion

(1) Effective sealing measures are to be taken to prevent the propeller shaft and turning gear of Z propulsion arrangement from being corroded by sea water.

(2) 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) Overall idling test;

(3) Pitch control test (where applicable);

(4) Load test (where applicable)

(5) Hydraulic test of pressure element;

(6) Functional test of alarm/safety;

(7) Tightness test;

(8) Gear engagement inspection

(9) Safety valve/spill valve setting test;

(10) Turning test;

(11) Up-and-down/outward swaying test (where applicable);

(12) Calibration test of zero rudder angle (where applicable).

Whether the load test items are performed depends on the assessment conducted by CCS on the manufacturing works. If necessary, the product with a large power may be subjected to a part-load test with partial load reduced. On completion of installation on board, it is to be subjected to a test on board. The load test may be replaced by the on-board test data of the product of the same type.

8.3 Type test methods and requirements

(1) Visual inspection

① The components/parts such as upper/lower gearbox, rudder, shafting system and hydraulic system 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.

③ The pipelines of hydraulic units are to be arranged regularly and bended smoothly; long pipelines are to be fixed; and flexible hoses are to be short as much as possible without abrupt bends or twisting

(2) Overall idling test

① Products without a propeller may be driven by the test device on the test bench at the manufacturing works for operation test.

② The rotation speed is to be gradually increased to the rated speed. The test is to last for at least 3 h.

③ The lubrication oil temperature of the gearbox is to be recorded during the test.

④ The system is to be able to work smoothly and steadily without abnormal noise and leakage.

(3) Pitch control test (where applicable)

① The Z propulsion arrangement with a controllable-pitch propeller is to be subjected to tests on pitch control time, pitch control stability, pitch control accuracy, pitch indication accuracy, etc.

② At the rated speed of the controllable-pitch propeller, the time required for the change of pitch angle from 1/3 positive maximum (or 1/3 negative maximum) to 1/3 negative maximum (or 1/3 positive maximum) is not to exceed 15 s.

③ The system is to work smoothly and steadily during the pitch control process. The deviation between the pitch angle indicator and the actual pitch angle of the propeller is not to exceed ±1 °.

(4) Load test

① The product may be driven by the test device on the test bench at the manufacturing works for load test.

② At the rated speed, the propeller blade is to be subjected to hydrodynamic and centrifugal loads simulating the propeller blade working condition.

③ The loads are to be gradually increased until the rated speed is achieved. The test is to last for at least 3 h

④ The working pressures of all oil pumps and cooling water pumps and the lubricating oil temperature and temperature rise of the gearbox are to be recorded during the test.

⑤ The temperature of the sliding bearing is not to exceed 70℃, and the temperature of the rolling bearing is not to exceed 80℃.

⑥ The system is to be able to work smoothly and steadily without abnormal noise and leakage.

(5) Hydraulic test of pressure element

The hydraulic and pneumatic pipelines are to be subjected to hydraulic tests to a pressure of 1.5 times the design pressure without leakage.

(6) Functional test of alarm/safety

① By the method of manually changing oil levels and oil (air) pressures and temperatures or manually analog input of faults, the alarm against such faults as low pressure of lubricating oil (if fitted with lubricating oil pump), high temperature of lubricating oil, low level of hydraulic oil, low pressure of hydraulic oil, high temperature of hydraulic oil (if fitted with oil cooler), too high pressure difference of hydraulic oil filter (if fitted with oil filter) and low pressure of clutch is to be inspected.

② Alarm values of the above-mentioned items are to meet the requirements of design plan.

③ All alarms are to be indicated in the bridge.

(7) Tightness test

① The components of Z propulsion arrangement such as upper/lower gearbox, steering gearbox and stem tube are to be subjected to a hydraulic test to 0.2 MPa on completion of fabrication and a tightness test on completion of assembly. The tightness test may be conducted with a liquid at a pressure of 0.1 MPa or compressed air at a pressure of 0.03 MPa by the soap liquid application method. Leakage is not allowed.

② For the turning test of oil distributor sealed bearing, the amount of leakage and the temperature under specified pressure and rated speed are to be in line with those indicated in the approved plan.

(8) Gear engagement inspection

① The contact condition of gear pair is to be verified by uniformly applying a thin layer of pigment under appropriate load.

② The gear contact spots are not to be less than the value provided in Table 10.4.3.1 of Chapter 10, Part Three of CCS *Rules for Classification of Sea-going Steel Ships.*

(9) Safety valve/spill valve setting test

① Safety valves/spill valves in the system are to be subjected to setting tests by the method of changing the pressures of hydraulic and control systems.

② The set values of safety valves/spill valves are to meet the requirements of design plan.

(10) Turning test

① The steering system is to be respectively turned clockwise and counterclockwise under static and dynamic conditions (turning and non-turning condition) for 360 ° for five times on the test bench at the manufacturing works.

② The time and pressure of rudder movement and the lubricating oil temperature and temperature rise of the gearbox are to be measured during the test.

③ The time of rudder movement is to meet the requirements of design plan.

④ The temperature of sliding bearing is not to exceed 70 ℃, and temperature of rolling bearing is not to exceed 80 ℃.

⑤ The system is to be able to work smoothly and steadily without abnormal noise and leakage.

(11) Up-and-down/outward-swaying test (where applicable)

① The liftable/outward-swaying rudder propeller is to be subjected to an up-and-down/outward-swaying test on the test bench at the manufacturing works.

② The liftable/outward-swaying components are to be able to operate flexibly, smoothly and steadily without abnormal noise.

③ The up-and-down travel and the maximum outward-swaying angle are to meet the requirements of design plan.

(12) Calibration test of zero rudder angle (where applicable)

The steering control system is to be zero-calibrated based on the mechanical zero with an error of ±1.8 °.

9 Unit/batch inspection

9.1 Inspection content

(1) Inspections of Z propulsion arrangement are to include document examination and in-process inspections and functional tests.

(2) In-process inspections are to mainly include material tests, non-destructive tests of main parts, inspections of manufacturing and assembly qualities of parts, etc.

(3) The main parts such as power shaft, vertical shaft, propeller shaft, gear shaft, gear, coupling and important bolt are to be subjected to mechanical property tests of materials.

(4) The Z propulsion arrangement 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 or outsourced parts;

(3) Inspection, measurement and test conditions of manufacturing works, a list of test and inspection equipment and copies of valid verification 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) Overall idling test;

(3) Pitch control test (where applicable);

(4) Hydraulic test of pressure element;

(5) Functional test of alarm/safety;

(6) Tightness test;

(7) Gear engagement inspection;

(8) Safety valve/spill valve setting test;

(9) Turning test;

(10) Up-and-down/outward-swaying test (where applicable);

(11) Calibration test of zero rudder angle.

9.4 For the Z propulsion arrangement type-modified after type test, CCS may reduce relevant test items or test time during the inspection provided that its maximum transmission power or maximum torque is not more than that of the prototype and its construction is similar to or main components are carried over from the prototype. The overall idling test may be reduced to 2 h.