GUIDANCE NOTES
GD015-2024

CHINA CLASSIFICATION SOCIETY

TECHNICAL GUIDELINES FOR SEMI-SUBMERGED PROPELLER PROPULSION UNITS

2024

Effective from 1 October 2024

Beijing

CONTENTS

1 General Provisions

1.1 General requirements

1.1.1 The Guidelines are applicable to plan approval and inspection of semi-submerged propeller propulsion units installed on high-speed crafts navigating in inland waters and sea. If a semi-submerged propeller unit uses a mechanical connection structure not fully equivalent to that defined in 1.2.1 of the Guidelines, reference may be made to the requirements of the Guidelines. For the use of semi-submerged propeller propulsion units on non-high-speed crafts, reference may also be made to the requirements of the Guidelines.

1.1.2 In addition to the requirements of the Guidelines, semi-submerged propeller propulsion units are to comply with applicable provisions of corresponding CCS Rules according to the ship characteristics and navigation areas.

1.1.3 Semi-submerged propeller propulsion units are to have sufficient strength, capability and necessary support system so as to provide effective thrust and steering control for the ship under all operation conditions.

1.1.4 The design and arrangement of semi-submerged propeller propulsion units are to comply with predetermined service environmental conditions.

1.1.5 Materials for manufacturing components of semi-submerged propeller propulsion units are to comply with relevant provisions of CCS Rules for Materials and Welding.

1.1.6 Equivalent design requirements different from the requirements of the Guidelines may be accepted subject to special consideration by CCS.

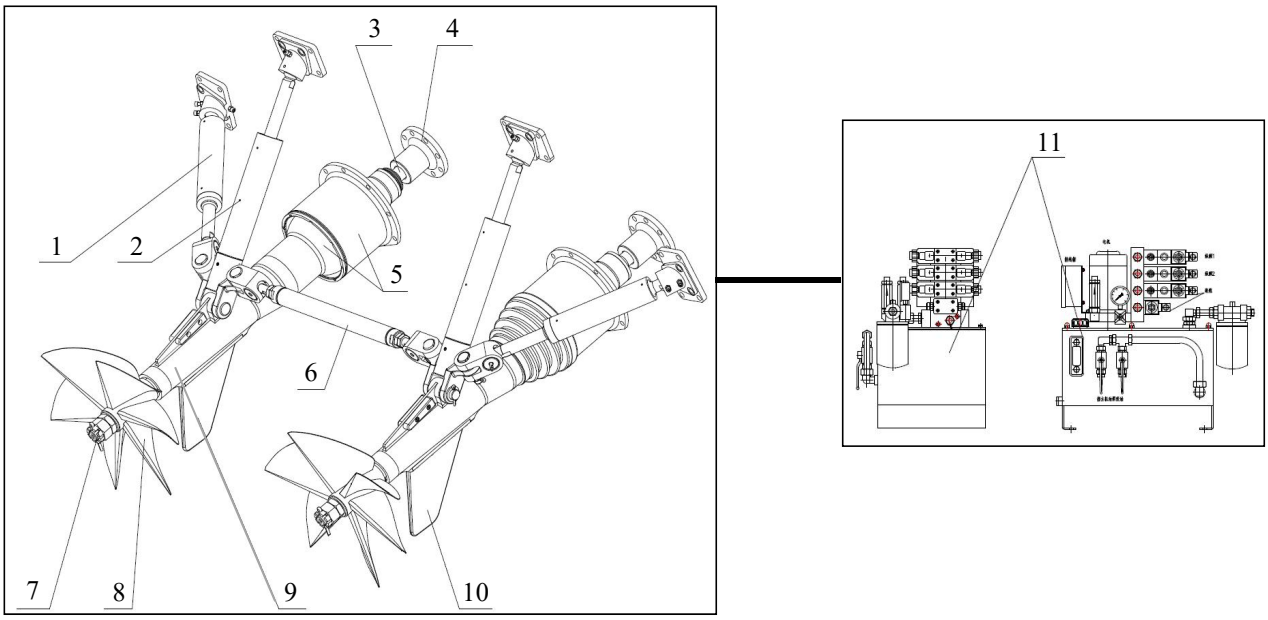
1.1.7 Ships provided with semi-submerged propeller propulsion units and complying with the requirements of the Guidelines may be granted with a class notation for semi-submerged propeller propulsion units: Semi-submerged Propeller .

1.2 Definitions

1.2.1 Semi-submerged propeller propulsion units

Semi-submerged propeller is a kind of special propeller with partial of blades above water under normal working condition, which is also called as surface propeller and can be widely used for high-speed crafts navigating in inland waters and sea. Semi-submerged propeller propulsion unit is composed of two parts, semi-submerged propeller and its auxiliary components as well as direction control unit. The semi-submerged propeller propulsion unit is driven by the prime mover to adjust thrust by changing revolving speed of propeller and achieve ship direction changing and matching of ship and propeller movement by maneuvering steering gear (steering cylinder and trim cylinder).

Semi-submerged propeller propulsion units are divided into trim adjustable type and trim fixed type according to whether they are adjustable, and trim adjustable type semi-submerged propeller propulsion units are divided into cylinder built-in type and cylinder external type according to arrangement of cylinder. Semi-submerged propeller propulsion units can adopt single, double or multiple link scheme for use. Figure 1.2.1 is schematic diagram of external structure of double-connection cylinder.



1 Steering cylinder 2 Trim cylinder 3 Input shaft 4 Flange coupling
5 Ball seat and sphere 6 Connecting rod 7 Propeller shaft 8 Propeller 9 Bracket
10 Rudder plate 11 Hydraulic power unit and control box

Figure 1.2.1 Schematic diagram of structure of semi-submerged propeller propulsion unit

1.2.2 Steering cylinder

A component driving the propulsion unit (sphere, bracket, propeller shaft, propeller and rudder plate, etc.) to swing left and right (direction adjustment). See 1 of Figure 1.2.1.

1.2.3 Trim cylinder

A component driving the propulsion unit (sphere, bracket, propeller shaft, propeller and rudder plate, etc.) to swing up and down (trim adjustment). See 2 of Figure 1.2.1.

1.2.4 Ball seat

A part which is installed on ship stern plate, with sphere, input shaft and ball lining inside, see 5 of Figure 1.2.1.

1.2.5 Sphere

A part which is installed inside ball seat, with flange end connected with bracket and with cardan joint inside, and can swing within certain angle under the action of steering cylinder and trim cylinder. See 5 of Figure 1.2.1.

1.2.6 Connecting rod

A component connecting multiple driving gear. See 6 of Figure 1.2.1.

1.2.7 Propeller shaft

Propeller mounting shaft which turns propeller. See 7 of Figure 1.2.1.

1.2.8 Propeller

Equipment turning in air and water and converting output power of prime mover to thrust. See 8 of Figure 1.2.1.

1.2.9 Bracket

A component connecting steering cylinder, trim cylinder and connecting rod and supporting shafting. See 9 of Figure 1.2.1.

1.2.10 Rudder plate

A part which is installed below bracket, with certain rudder effect to stabilize course. See 10 of Figure 1.2.1.

1.2.11 Direction control unit

Steering mechanism, hydraulic power unit, power supply and control unit for controlling direction/trim (if any) of the semi-submerged propeller. See 1, 2 and 11 of Figure 1.2.1.

1.3 Plans and documents

1.3.1 Plans and documents to be submitted for approval:

(1) General assembly plan;

(2) Main parts plan (propeller shaft, input shaft, bracket, rudder plate, ball seat, sphere, trim cylinder, steering cylinder, propeller, sealing unit arrangement plan, connecting rod, pin, cardan, coupling, etc.);

(3) Schematic diagram of direction control unit as well as monitoring and alarm unit;

(4) Calculations (including calculations of shafting strength and vibration, propeller strength, bracket and rudder plate strength, spline strength, sphere and ball seat, cardan strength and cylinder, etc.);

(5) List of physical and chemical properties of main parts (individual submission may not be required if such contents have been contained in the plan);

(6) Test program.

1.3.2 Plans and documents to be submitted for information:

(1) Main performance specifications of product (individual submission may not be required if such contents have been contained in the plan);

(2) Acceptance standard;

(3) Product manual.

2 Design

2.1 Propeller

2.1.1 General requirements

(1) Propeller surface quality and size are to meet the requirements for design;

(2) Balance level of the propeller is to meet the requirements for design;

(3) Yield and fatigue strength assessment are to be carried out to the propeller.

2.1.2 Yield strength assessment

(1) In general, yield strength assessment is to be based on stress analysis method, e.g. finite element strength analysis. Solid element is to be adopted for finite element strength calculation, with mesh size not to be more than 1/50 of propeller diameter. Strength assessment criteria are to comply with a recognized industry standard or the maximum equivalent stress is not to be more than 0.7 times the material yield strength;

(2) Finite element strength calculation is to be based on ultimate load condition, and finite element strength calculation report is to include loads (experimental results or CFD calculation results, etc.), finite element strength analysis model diagram and explanations, calculation results (including deformation diagram, stress cloud chart, etc.) and description of stress criteria;

(3) For data and method used in the calculation, relevant test results or experience data may be

required when necessary.

2.1.3 Fatigue strength assessment

For fatigue analysis, a recognized industry method is to be applied, and fatigue strength calculation report is to include fatigue assessment method and descriptions, fatigue assessment results and description of adopted fatigue acceptance criteria. Fatigue strength assessment zones are to at least include but not limited to blade root, middle of trailing edge and maximum alternating stress zone. The number of fatigue stress calculation cycles is not to be less than 10^8.

2.1.4 Installation of propeller and propeller shaft

(1) Reliable measures against loosening and corrosion are to be taken for the screws and nuts securing propeller and its accessories;

(2) The propeller shaft or joint in way of the cylinder and the cone of the propeller hub hole is to have a smooth transition without protrusion or rounded corner. The contact area between propeller shaft cone and propeller hub is not to be less than 70% of the theoretical contact area;

(3) If spline installation is adopted, the requirements of 2.4 of the Guidelines are to be complied with.

2.2 Shaft diameter

2.2.1 For semi-submerged propeller propulsion units of seagoing ships the length of which is equal to or greater than 20 m, the shaft diameter is to comply with the applicable requirements of 6.7.2 of Chapter 6 of CCS Rules for Classification and Construction of Seagoing High-Speed Craft.

2.2.2 For semi-submerged propeller propulsion units of inland waterway vessels the length of which is equal to or greater than 24 m, the shaft diameter is to comply with the applicable requirements of 4.7.2 of Chapter 4 of CCS Rules for Construction of Inland Waterway High-Speed Craft.

2.2.3 When a seagoing ship with length less than 20 m is provided with semi-submerged propeller propulsion unit, the shaft diameter is to comply with the applicable requirements of 6.7.2 of CCS Rules for Classification and Construction of Seagoing High-Speed Craft, and if shaft material is alloy steel or stainless steel, 0.8 times the calculated value of 6.7.2.1 may be taken for shaft diameter.

2.2.4 When an inland waterway vessel with length less than 24 m is provided with semi-submerged propeller propulsion unit, the shaft diameter is to comply with the applicable requirements of 4.6.2.1 of Chapter 4 of CCS Rules for Construction of Inland Waterway Small Boats, and if shaft material is alloy steel or stainless steel, 0.8 times the calculated value of 4.6.2.1 may be taken for shaft diameter.

2.3 Coupling and flange

2.3.1 For semi-submerged propeller propulsion units of seagoing ships the length of which is equal to or greater than 20 m, the coupling and flange are to comply with the applicable requirements of 6.7.5 of Chapter 6 of CCS Rules for Classification and Construction of Seagoing High-Speed Craft.

2.3.2 For semi-submerged propeller propulsion units of inland waterway vessels the length of which is equal to or greater than 24 m, the coupling and flange are to comply with the applicable requirements of 4.7.6 of Chapter 4 of CCS Rules for Construction of Inland Waterway

High-Speed Craft.

2.3.3 When a seagoing ship with length less than 20m is provided with semi-submerged propeller propulsion unit, the coupling and flange are to comply with the applicable requirements of 4.4.1 of Chapter 4 of CCS Rules for Classification of Small Sea-Going Boats.

2.3.4 When an inland waterway vessel with length less than 24 m is provided with semi-submerged propeller propulsion unit, the coupling and flange are to comply with the applicable requirements of 4.6.3 of Chapter 4 of CCS Rules for Construction of Inland Waterway Small Boats.

2.4 Spline

2.4.1 The spine is subject to strength assessment. The crushing stress on the working tooth surface of the spline is not to exceed the allowable crushing stress.

2.5 Sphere and ball seat

2.5.1 In general, yield strength assessment of sphere and ball seat is to be based on stress analysis method, e.g. finite element strength analysis, and the maximum equivalent stress is not to be greater than 0.5 times the material yield strength. Load sources are to be indicated in the calculation report, and for data and methods used in the calculation, relevant test result or empirical data may be required when necessary.

2.5.2 Before assembling the sphere and the ball seat, the actual contact area between the sphere and the ball seat is to be checked, and the contact area is not to be less than 80% of the theoretical contact area.

2.6 Bracket and rudder plate

2.6.1 In general, yield strength assessment of bracket and rudder plate is to be based on stress analysis method, e.g. finite element strength analysis, and the maximum equivalent stress is not to be greater than 0.5 times the material yield strength. Load sources are to be indicated in the calculation report, and for data and methods used in the calculation, relevant test result or empirical data may be required when necessary.

2.7 Direction control unit

2.7.1 For semi-submerged propeller propulsion units of seagoing ships the length of which is equal to or greater than 20 m, the direction control unit is to comply with the applicable requirements of Section 9, Chapter 6 of CCS Rules for Classification and Construction of Seagoing High-Speed Craft. When ship length is less than 20 m, the direction control unit is to comply with the applicable requirements of Section 8, Chapter 4 of CCS Rules for Construction of Coastal Boats.

2.7.2 For semi-submerged propeller propulsion units of inland waterway vessels the length of which is equal to or greater than 24 m, the direction control unit is to comply with the applicable requirements of Section 8, Chapter 4 of CCS Rules for Construction of Inland Waterway High-Speed Craft. When ship length is less than 24 m, the direction control unit is to comply with the applicable requirements of Section 7, Chapter 4 of CCS Rules for Construction of Inland Waterway Small Boats.

2.7.3 Trim angle adjustment range and time as well as steering angle adjustment range and time

are to meet the design requirements.

2.7.4 Steering system is at least to be capable of keeping current rudder position in case of the failure of the unit.

2.8 Monitoring and alarm

2.8.1 Steering angle and trim angle (if fitted with trim components) of semi-submerged propeller propulsion units are at least to be capable of being displayed at navigation position.

2.8.2 Semi-submerged propeller propulsion units are at least to be provided with the following visual and audible alarms at navigation position, unless a non-power maneuvering is conducted:

(1) Low hydraulic oil level;

(2) High hydraulic oil temperature (if fitted with oil cooler);

(3) Low lubricating oil pressure (if fitted with lubricating oil circulating system) and/or low lubricating oil level;

(4) High pressure difference of hydraulic oil filter (if fitted with oil filter);

(5) Power failure of direction control unit;

(6) Power failure of alarm and monitoring system.

2.9 Vibrational assessment

2.9.1 For semi-submerged propeller propulsion units of seagoing ships, the shafting vibration is to comply with the applicable requirements of Section 7, Chapter 6 of CCS Rules for Classification and Construction of Seagoing High-Speed Crafts.

2.9.2 For semi-submerged propeller propulsion units of inland waterway vessels, the shafting vibration is to comply with the applicable requirements of 4.7.7, Chapter 4 of CCS Rules for Construction of Inland High-Speed Crafts.

2.9.3 When a seagoing ship with length less than 20 m is provided with a semi-submerged propeller propulsion unit, shafting vibration assessment and calculation may not be required.

2.9.4 When an inland waterway vessel with length less than 24 m is provided with a semi-submerged propeller propulsion unit, shafting vibration assessment and calculation may not be required.

2.10 Other requirements

2.10.1 Effective anti-corrosion measures are to be taken to prevent seawater corrosion or damage to the semi-submerged propeller propulsion units.

2.10.2 The anti-corrosion measures used in semi-submerged propeller propulsion units are not to adversely affect the water environment.

2.10.3 Effective anti-loosening and vibration-reducing measures (such as bolt anti-loosening measures, vibration-reducing springs, etc.) are to be taken to avoid adverse effects on the use of equipment components and devices caused by vibration.

3 Product Inspection

3.1 General requirements

3.1.1 Requirements for inspection mode

(1) Unit/batch inspection is to be carried out after drawing examination and approval;

(2) The first product of the electric part of the direction control unit is to be subject to type test

according to CCS Guidelines for Type Approval Test of Electric and Electronic Products.

3.1.2 Certification requirements

(1) Hydraulic power unit, electric control box, hydraulic cylinder, flexible hose assembly, oil cooler (where applicable) and accumulators (where applicable) are to be furnished with Marine Product Certificate;

(2) Propeller, propeller shaft, input shaft, sphere, ball seat, bracket, cardan, coupling and connecting bolt are to be furnished with Marine Product Certificate;

(3) If purchased parts cannot meet the certification requirements, inspection is to be carried out according to the requirements of CCS Rules.

3.2 Materials and welding

3.2.1 Raw materials and main parts (propeller, shaft, coupling and connecting bolt, oil cylinder, sphere, ball seat, bracket and cardan) of semi-submerged propeller propulsion unit are to be subject to material test and non-destructive testing according to CCS Rules for Materials and Welding.

3.2.2 For welding procedures of main welding structures in a semi-submerged propeller propulsion unit, the approval of welding procedures is to be carried out according to relevant requirements of CCS Rules for Materials and Welding prior to manufacturing.

3.3 Requirements for inspection and tests

3.3.1 All main materials and parts are to be inspected and tested according to the requirements of the Guidelines and relevant Rules and be certified .

3.3.2 Inspection of semi-submerged propeller propulsion unit includes document review, inspection during manufacturing and performance tests of final products.

3.3.3 Inspection during manufacturing mainly includes material test, pressure/tightness test, non-destructive testing of main parts, static balance and dynamic balance test of propeller, welding of parts, check of sphere and thrust ring assembly contact area and assembly quality inspection.

3.3.4 Prototype test is to be carried out on the first product of new model according to the approved test program, which is at least to include the following items:

(1) visual inspection;

(2) dimension inspection;

(3) hydraulic/tightness test;

(4) function and effectiveness test (including electric control, monitoring and alarm);

(5) non-load running test;

(6) running test with load;

(7) endurance test;

(8) type test of electric part of direction control unit.

3.3.5 Unit/batch inspection test items are at least to include the following items:

(1) visual inspection;

(2) dimension inspection;

(3) hydraulic/tightness test;

(4) function and effectiveness test (including electric control, monitoring and alarm);

(5) non-load running test;

(6) running test with load.

3.3.6 Hydraulic test

Piping of hydraulic system of semi-submerged propeller propulsion unit are to be subject to hydraulic test under 1.5 times the design pressure, and after installation onboard they are to be subject to, together with the ship piping accessories, the tightness test under the 1.25 times the design pressure.

3.3.7 Tightness test

Air tight pressure test is to be carried out on the sphere, ball seat and bracket under a pressure of 0.2 MPa for 5 minutes without leakage.

Air tight pressure test is to be carried out on the sphere, ball seat and bracket after assembly is completed under a pressure of 0.2 MPa for 30 minutes without leakage.

3.3.8 Non-load running test

Semi-submerged propeller propulsion unit is to have non-load operation tests in the following conditions and to ensure smooth operation without abnormal vibration, temperature rise or noise:

(1) at the maximum rudder angle, trim angle, not less than 50% of the design speed, operation not less than 5 min;

(2) at zero rudder angle, at 25%, 50%, 75%, 90% and 100% design speed, respectively, each operation not less than 5 min. .

3.3.9 Function and effectiveness test

(1) Adjustment range and time of trim angle and steering angle of semi-submerged propeller propulsion unit are to meet the requirements of 2.7.3 of the Guidelines, and the location of mechanical zero position is to be clearly marked;

(2) Testing of the monitoring and alarm system is to meet the requirements of 2.8.2 of the Guidelines;

(3) For devices with multiple control positions, the control position switching function is to work properly.

3.3.10 Running test with load

Semi-submerged propeller propulsion units are to run with loads in the condition not less than 95% design torque and 80% design engine speed for 2 hours with all systems in normal operation and without alarm.

3.3.11 Endurance test

A newly developed model is to be verified by the endurance test. The endurance test of the semi-submerged propeller propulsion unit may be carried out according to the cycle conditions shown in Table 3.1.11. Each cycle is 10 h. The propulsion unit can stop as needed between complete cycles or run continuously. After accumulative running of 500 hours with all systems in normal operation, the unit is to be disassembled and the components and parts are to be checked.

Endurance test cycle duration **Table 3.1.11**

No.	Condition (%)	Operation duration (min)
1	minimum stable engine speed	10
2	50	40
3	75	40
4	90	60
5	100	450
The switch of each condition is not to exceed 1 min; The corresponding engine speed of each gear of the marine main engine is determined by $Pe=Cn^3$, and the marine auxiliary engine runs according to the rated engine speed.		

If non-main parts are damaged during the test, the engine is allowed to shut down for maintenance once every 100 h test duration on average, and each shutdown duration does not exceed 45 min. Test failures are to be recorded. If there is a forced shutdown due to one of the following conditions, the endurance test is to be repeated from cycle 1:

(1) The main parts are damaged and the engine is forced to shut down, e.g. the drive shaft, sphere, etc.;

(2) The engine is forced to shut down twice due to the failure of the same part;

(3) The repair time of the forced shutdown failure exceeds 2 h.

During the endurance test, shutdown maintenance as required is allowed, but the endurance test conducted under the cycle condition is to keep each cycle complete. The content, frequency and time of shutdown maintenance is to be negotiated by the manufacturer, the user and the relevant institutions, and stipulated in the endurance test program. The manufacturer is not to make use of the shutdown maintenance to deal with failures of the semi-submerged propeller propulsion unit.

After the endurance test, the performance review test is to be carried out, and the measured performance parameters are to be within the design values.

4 Survey items during construction

4.1 Arrangement and installation examination

4.1.1 After installation onboard, the installation position of the propulsion unit base (ball seat flange, cylinder support) and the hull stern plate is to be examined for dimensions in accordance with the requirements of approved drawings and technical (procedural) documents.

4.1.2 After installation onboard, the examination of the contact area of propeller and propeller shaft cone is to meet the requirements of the approved drawings.

4.1.3 After installation onboard, the center line of propulsion unit shafting, zero position and limit angle of the steering gear are to be checked in accordance with the requirements of the approved drawings.

4.2 Mooring test

4.2.1 Tightness test of hydraulic pipes

The whole ship is to be subject to tightness test under 1.25 times the design pressure after installation of hydraulic pipes and accessories. Leakage is not to occur.

4.2.2 Function and effectiveness test

Function and effectiveness test is to be carried out after the ship is launched and commissioning of main engine is completed. Semi-submerged propeller propulsion units are to operate smoothly

with all systems in normal operation (including electric control, monitoring and alarm), and alarm function simulation test is to be carried out.

4.3 Sea trial

4.3.1 Test is to be carried out according to the approved ship sea trial program to meet the design index. Each system is in normal operation.

5 Survey items after construction

5.1 Annual survey items

5.1.1 General inspection is to be carried out to confirm that the equipment is running efficiently. When necessary, steering gear and accessories of semi-submerged propeller propulsion units (including components, connecting rod and brackets of steering cylinder and trim cylinder) are to be subject to inspection and tests.

5.1.2 Operational status of steering gear as well as relevant device and direction control unit of propulsion units (including steering angle zero position and steering time, adjustment range and duration, trim angle zero position and trim adjustment range and duration) is to be inspected and tested.

5.1.3 It is to be confirmed that various alarms required for electric, hydraulic power-operated, or electro-hydraulic direction control units are operating satisfactorily and that the re-charging arrangements for hydraulic power-operated direction control units are being well maintained.

5.2 Intermediate survey items

5.2.1 The same as annual survey items listed in 5.1.

5.3 External bottom examination

5.3.1 The propeller and propeller rudder plate are to be examined for corrosion.

5.3.2 The fitting of steering gear parts is to be examined, and brackets, connecting rods, rudder plate connecting nuts, bolts, pins, etc., are fixed reliably without loosening.

5.3.3 Propulsion units are to be subject to visual inspection, with focus on the fixing conditions of ball seat and sphere, propeller blade and screws as well as other securing devices. Condition of sealing device of propeller shaft is to be verified.

5.3.4 The fixing, corrosion and coating of the anti-corrosion zinc block of the unit is to be examined.

5.3.5 The connection between the root flange and the hull stern plate is to be examined.

5.4 Special survey items

5.4.1 In addition to items listed in 5.1, the following applicable items are to be inspected:

(1) all shafts (e.g. propeller shaft, input shaft, cardan shaft) and shaft bearings, spheres and thrust rings, oil sealing glands of the propulsion unit;

(2) direction control unit (steering gear hydraulic cylinder);

(3) system safe pressure release valve and its setting value;

(4) accumulator pressure value (where applicable);

(5) condition of anti-corrosion device.

5.5 Propeller shaft and propulsion unit inspection

5.5.1 Inspection interval

When semi-submerged propeller propulsion units are used as main propulsion units, the inspection interval is not to be more than 5 years.

5.5.2 The unit is to be disassembled for the inspection of the following items:

(1) Shaft (special attention to shaft seal), key slot, shaft cone and flange fillet, and NDT where necessary;

(2) Cross cardan shaft bearing and friction pair clearance, and record;

(3) Contact surface and clearance between sphere and thrust ring, and record;

(4) Inspection of oil glands;

(5) Hydraulic cylinder and seal thereof.