



GUIDANCE NOTES
GD 13-2019

CHINA CLASSIFICATION SOCIETY

TECHNICAL GUIDELINES FOR
SEMI-SUBMERGED PROPELLER
PROPULSION UNITS

2019

Effective from 1 August 2019

Beijing

CONTENTS

1 General Provisions	1
1.1 General requirements	1
1.2 Definitions	1
1.3 Plans and documents	3
2 Design	4
2.1 Propeller	4
2.2 Shaft diameter	5
2.3 Coupling and flange	5
2.4 Spline	5
2.5 Bracket and rudder plate	5
2.6 Direction control unit	5
2.7 Monitoring and alarm	6
2.8 Vibrational assessment	6
3 Product Inspection	7
3.1 General requirements	7
3.2 Materials and welding	7
3.3 Requirements for inspection and tests	7
4 Survey items during construction	10
4.1 Mooring test	10
4.2 Sea trial	10
5 Survey items after construction	11
5.1 Annual survey items	11
5.2 Intermediate survey items	11
5.3 Special survey items	11
5.4 Docking survey items	11
5.5 Propeller shaft and stern tube inspection	12

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.

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.

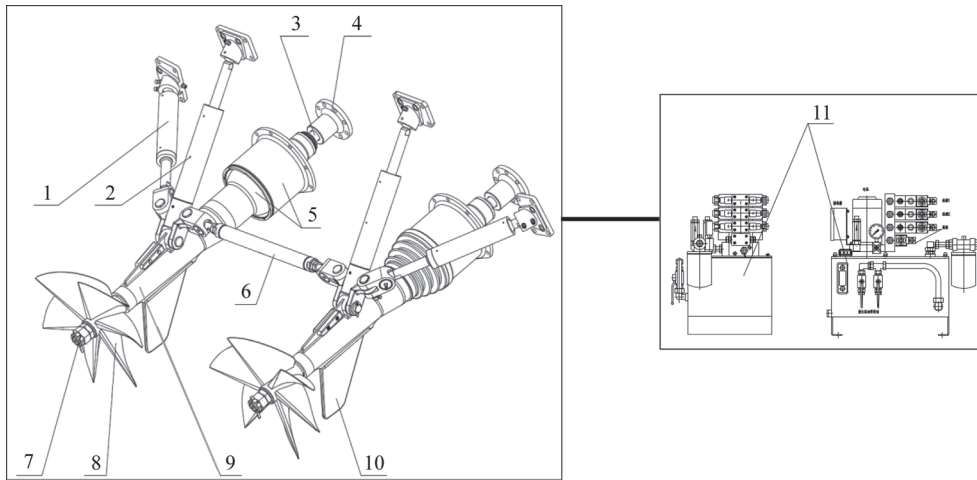
1.1.7 Ships provided with semi-submerged propeller propulsion units and complying with the requirements of the Guidelines may be granted with a class notation for semi-submerged propeller propulsion units: Semi-submerged Propeller .

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 Direction control unit

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 or 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

Hydraulic power unit, power supply and control system for controlling direction of semi-submerged propeller. See 11 of Figure 1.2.1.

1.3 Plans and documents

1.3.1 Plans and documents to be submitted for product plan approval:

- (1) Main performance specifications of product (individual submission may not be required if such contents have been contained in the plan);
- (2) General assembly plan;
- (3) 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.);
- (4) Schematic diagram of direction control unit as well as monitoring and alarm unit (refer to the requirements for plan submission of similar units in CCS Guidelines for Product Inspection);
- (5) Calculations (including calculations of shafting strength and vibration, propeller strength, bracket and rudder plate strength, spline strength, cardan strength and cylinder, etc.);
- (6) Acceptance standard (for reference);
- (7) List of physical and chemical properties of main parts (individual submission may not be required if such contents have been contained in the plan);
- (8) Test program;
- (9) Product manual (for reference).

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;
- (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 calculation 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.

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;
- (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 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 Crafts.

2.2.2 For semi-submerged propeller propulsion units of inland waterway vessels, 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 Inland High-Speed Crafts.

2.2.3 When the ship with length less than 20m is provided with semi-submerged propeller propulsion unit, the shaft diameter is to comply with the applicable requirements of 4.4.1 of Chapter 4 of CCS Rules for Construction of Coastal Boats, and if shaft material is alloy steel or stainless steel, 0.8 times the calculated value may be taken for shaft diameter.

2.3 Coupling and flange

2.3.1 For semi-submerged propeller propulsion units of seagoing ships, 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 Crafts.

2.3.2 For semi-submerged propeller propulsion units of inland waterway vessels, the coupling and flange are to comply with the applicable requirements of 6.7.6 of Chapter 6 of CCS Rules for Classification and Construction of Inland High-Speed Crafts.

2.3.3 When the 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 4.4.4 of Chapter 4 of CCS Rules for Construction of Coastal Boats.

2.4 Spline

2.4.1 The crushing stress on the working tooth surface of the spline is not to exceed the allowable crushing stress so as to avoid crushing and wear of spline flank.

2.5 Bracket and rudder plate

2.5.1 In general, yield strength assessment is to be based on stress analysis method, e.g. finite element strength analysis, and strength assessment criteria is to comply with a recognized industry standard. 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.

2.6 Direction control unit

2.6.1 For semi-submerged propeller propulsion units of seagoing ships, 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 Crafts. When ship length is less than 20m, the direction control unit is to comply with the applicable requirements of Section 8, Chapter 4 of CCS Rules for Construction of Coastal Boats.

2.6.2 For semi-submerged propeller propulsion units of inland waterway vessels, the direction control unit is to comply with the applicable requirements of Section 8, Chapter 6 of CCS Rules for Classification and Construction of Inland High-Speed Crafts.

2.6.3 Trim angle adjustment range and time as well as steering angle adjustment range and time are to meet the design requirements.

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

2.7 Monitoring and alarm

2.7.1 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.

2.7.2 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) or low lubricating oil level;
- (4) High pressure difference of hydraulic oil filter (if fitted with oil filter);
- (5) Power failure of direction control system;
- (6) Power failure of alarm and monitoring system.

2.8 Vibrational assessment

2.8.1 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.

2.8.2 For semi-submerged propeller propulsion units of inland waterway vessels, the shafting vibration is to comply with the applicable requirements of 6.7.7, Chapter 6 of CCS Rules for Classification and Construction of Inland High-Speed Crafts.

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

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 and hydraulic cylinder are to be furnished with Marine Product Certificate;
- (2) Propeller, propeller shaft, input shaft, 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, bracket and universal coupling) 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 and assembly quality inspection.

3.3.4 Prototype test is to be carried out on the first product of new design under certain power 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 30 minutes without leakage.

3.3.8 Non-load running test

Semi-submerged propeller propulsion unit is to run smoothly without obvious vibration or abnormal noise under design speed during non-load operation.

3.3.9 Function and effectiveness test

Adjustment range and time of trim angle and steering angle of semi-submerged propeller propulsion unit are to meet the requirements of 2.6.3 of the Guidelines.

3.3.10 Running test with load

Semi-submerged propeller propulsion units are to run smoothly for 2 hours with all systems in normal operation and without alarm.

3.3.11 Endurance test

Endurance test is to be carried out to evaluate a newly developed type. Semi-submerged propeller propulsion units are to simulate actual operation condition for accumulative running of 500 hours with all systems in normal operation and without alarm. Then parts are to be disassembled and checked.

4 Survey items during construction

4.1 Mooring test

4.1.1 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.

4.1.2 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.

4.2 Sea trial

4.2.1 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 Visual inspection is to be carried out to confirm that the equipment are in good condition.

5.1.2 When applicable, 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.

5.1.3 Operational status of steering gear as well as relevant device and control system of semi-submerged propeller propulsion units (including steering angle and steering time, trim angle and trim adjustment time) is to be inspected and tested.

5.1.4 It is to be confirmed that various alarms required for hydraulic power-operated, electric and electro-hydraulic steering gears are operating satisfactorily and that the re-charging arrangements for hydraulic power-operated steering gears are being well maintained.

5.2 Intermediate survey items

5.2.1 The same as annual survey items listed in 5.1.

5.3 Special survey items

5.3.1 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) and all shaft bearings of main propulsion system;
- (2) direction control unit;
- (3) system safe pressure release valve and its setting value.

5.4 Docking survey items

5.4.1 Visible parts of bracket, connecting rod and rudder plate of semi-submerged propeller propulsion units are to be inspected.

5.4.2 Visible parts of propeller and stern bearing are to be examined. Effectiveness of sealing device (if fitted) is to be ascertained and recorded.

5.4.3 Semi-submerged propeller propulsion units are to be subject to visual inspection, with focus on the conditions of ball seat and sphere, propeller blade, bolt lock and other securing devices. Condition of sealing device of propeller shaft is to be verified.

5.5 Propeller shaft and stern tube 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 2 years.

5.5.2 Inspection range

- (1) Shaft, lining (especially for joints and ends), key slot, cone and flange fillet;
- (2) Surface cracks are to be detected around key slot;
- (3) Non-destructive testing is to be carried out at flange fillet at shaft end which is connected by the integral flange;
- (4) Inspection of oil glands.