



Guideline No.M-14 (201510)

M-14 Stern Shaft Sealing Apparatus

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Foreword

This Guideline is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

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Stern Shaft Sealing Apparatus

1 Application

1.1 This Guideline applies to stern shaft sealing apparatuses of oil lubrication and water lubrication types, which may be taken as a reference for other types of stern shaft sealing apparatus.

1.2 This Guideline applies to the approval and product inspection of stern shaft sealing apparatuses.

2 Basis for approval and inspection

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

- (1) Chapter 3, Part One and Chapter 11, Part Three of *CCS Rules for Classification of Sea-Going Steel Ships*;
- (2) Chapter 8, Part Two of *CCS Rules and Regulations for the Construction and Classification of Inland Waterways Steel Ships*;
- (3) Part One of *CCS Rules for Materials and Welding*;

3 Terms and definitions

3.1 For definitions of product inspection, approval, type test, sample, and unit/batch inspection, refer to Article 3.1.2, Chapter 3, Part One of *CCS Rules for Classification of Sea-going Steel Ships*, and for the purpose of this Guideline, the terms and definitions given in *CCS Rules for Classification of Sea-going Steel Ships* apply.

3.2 Oil lubrication stern shaft sealing apparatus: Stern shaft sealing apparatus with lubricating oil as the working medium;

3.3 Water lubrication stern shaft sealing apparatus: Stern shaft sealing apparatus with water as the working medium;

3.4 Seal: Parts of stern shaft sealing apparatus which prevents leakage of lubrication and cooling medium in the stern tube.

3.5 Shaft bush: A bush mounted on the stern shaft of the stern shaft sealing apparatus to guard against corrosion and wear.

3.6 Seal body: Parts of oil lubrication stern shaft sealing apparatus connecting and matching with the front and rear end of the stern tube.

3.7 Grip ring: A split-type part of oil lubrication stern shaft sealing apparatus which is fixed to the stern shaft and, due to its gripping force and hence the friction against the stern shaft, rotates with

the latter.

3.8 Gland: An outer-end part of oil lubrication stern shaft sealing apparatus used for clamping and locating the oil seal;

3.9 Pad: Parts of oil lubrication stern shaft sealing apparatus used for clamping and locating the oil seal;

3.10 Water seal carrier: Parts of water lubrication stern shaft sealing apparatus used for placing and locating seals.

3.11 Airtight seal carrier: Parts of water lubrication stern shaft sealing apparatus used for clamping and locating the pneumatic tire.

3.12 Drive grip ring: A split-type part of water lubrication stern shaft sealing apparatus which is fixed to the stern shaft and, due to its gripping force and hence the friction against the stern shaft, rotates with the latter.

3.13 End sealing cover: Parts of water lubrication stern shaft sealing apparatus which constitutes a sealing pair with sealing rings to prevent leakage of lubrication and cooling medium.

3.14 Pneumatic tire: Parts which are inflated by compressed air to guard against axial seawater seepage into the water lubrication stern shaft sealing apparatus when the stern shaft is in a static state.

4 Plans and documents

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

(1) *Main Product Performance Specification Table*; the following performance parameters are usually to be defined: type of sealing apparatus, applicable working pressure, applicable working temperature, applicable linear velocity, dynamic leakage amount, outside diameter of wearable bush, material of sealing ring;

(2) *General Assembly Plan*; usually the following contents are required to be expressly stated:

- ① Relation between product structural type and parts, which may be explained by structural section view;
- ② Main technical parameters of products, structural dimension, shape and installation dimension;
- ③ Indication of main parts and part numbers, parts list: relevant parameters of main parts such as name, material designation, specification and plan number/standard number;
- ④ Relevant technical requirements on product manufacturing, assembling, installation and inspection;

(3) Plans of main parts and components;

Plans of main parts and components of oil lubrication stern shaft sealing apparatus include: shaft bush, oil seal, seal body, spring, grip ring, gland, pad, set bolt, etc.;

Plans of main parts and components of water lubrication stern shaft sealing apparatus include: end sealing cover, shaft bush, water seal, water seal carrier, airtight seal carrier, drive grip ring, set bolt, etc.;

(4) Data sheet of physicochemical properties of materials for main parts (or clearly stated on parts plans);

(5) Factory inspection program and type test program of products; usually the following information is required to be expressly stated:

- ① Test items and standard of qualification;
- ② Test method;
- ③ Requirements for measuring instrument;
- ④ Environmental condition requirements for test;
- ⑤ Requirements for test equipment, etc.

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

(1) Product Operation Instructions and maintenance instructions which are usually to contain following information:

- ① Main technical parameters of product;
- ② Working principle of product;
- ③ Product Installation Instructions;
- ④ Operation instructions;
- ⑤ Maintenance requirements;
- ⑥ Necessary safety warnings; emergency response to faults.

(2) Main process documents: such as heat treatment process of parts, surface treatment requirements of parts, foundry process of castings, etc.

(3) Templates of product nameplate, certificate of inspection, etc.

5 Materials and components

5.1 The parts of oil lubrication stern shaft sealing apparatus mainly include: shaft bush, oil sealing element, seal body, gland, pad, grip ring, spring, set bolt, etc.

5.2 The important parts of water lubrication stern shaft sealing apparatus mainly include: pneumatic tire, water sealing element, water seal carrier, airtight seal carrier, end sealing cover, drive grip ring, spring, shaft bush, set bolt, etc.

6 Design and technical requirements

6.1 Requirements for service conditions:

The service condition is to be taken into consideration at the time of design, such as medium, design linear velocity, design water depth (design pressure), ambient temperature, ship vibration, etc.; the stern shaft sealing apparatus is to be resistant to corrosion, vibration, high and low temperature, and wear to ensure the proper functioning of the stern shaft sealing apparatus under design conditions;

6.2 Material requirements:

The material selected for main parts of marine stern shaft sealing apparatus is to be suitable for the type, temperature and pressure of the medium used.

- (1) Materials resistant to seawater corrosion are to be used for main parts of stern shaft rear seal in contact with seawater;
- (2) Stainless steel materials resistant to seawater corrosion are to be used for parts of stern shaft rear seal such as set bolt and locking steel wire of rear seal for sea-going ships to avoid the sealing apparatus being damaged by falling off of set bolt and locking steel wire due to corrosion;
- (3) Wear-resistant materials are to be used for front shaft bush of oil lubrication stern shaft sealing apparatus; wear-resistant and corrosion-resistant materials are to be used for rear shaft bush of oil lubrication stern shaft sealing apparatus for sea-going ships; wear-resistant and corrosion-resistant materials are to be used for end sealing cover of water lubrication stern shaft sealing apparatus for sea-going ships;
- (4) Materials resistant to wear, corrosion of oil/seawater and temperature rise are to be selected for seals of sealing apparatus according to the working environment, and sufficient proofs are to be provided by the factory to show the selected materials meet the service requirement;
- (5) Corrosion-resistant stainless steel or alloy materials are to be selected for springs and the material properties are to comply with relevant design requirements.

6.3 Structural requirements:

- (1) The oil lubrication stern shaft sealing apparatus is to be equipped with oil chamber and circulating oil tank and each oil chamber is to be filled with lubricating oil at the time of installation to avoid dry friction of the oil seal; the shaft bush is to be hollowed for heat dissipation at seal lip and for convection cooling of influent lubricating oil; the interface between sealing apparatus body and the front and rear ends of stern tube are to be equipped with sealing gasket; embedded fasteners and plugs are to be used for sealing apparatus with the top not protruding over the outline to prevent being winded by net rope;
- (2) For water seals used in the front end of stern tube of inland waterway ships, the gland box replacement measures when the ship is at anchor are to be provided; for the rubber ring type water seals, air seals and water seals are to be provided and associated cooling water joint, compressed air joint and vent and drain plug are to be equipped, and the surface between the body and the front and rear ends of the stern shaft is to be equipped with sealing washers; for gland box type water seals, two packing seals separated by a distributor are to be provided and associated cooling water joint and vent and drain plug are to be equipped; for leaf spring type water seals, the Ω -shaped elastomer is to compensate the wear of seal friction pair and the elastic deformation of shafting caused by vibration and shock automatically within the design range of displacement compensation; the shafting is to be free from mechanical shaft blockage under maximum possible bending deformation conditions; requirements for repairs of ship during voyage are to be met;
- (3) A device to prevent from being tangled by fishing nets is to be included in the structure design of stern shaft sealing apparatus for ships navigating in fishing areas frequently;
- (4) A silt arrestor is to be included in the structure design of stern shaft sealing apparatus for ships navigating in silty waters frequently;
- (5) All types of stern shaft sealing apparatus are to be provided with reliable fixing devices and all connecting bolts and plugs are to be installed with reliable locking devices;

6.4 Performance requirements:

- (1) Amount of leakage: The average amount of static leakage of oil/water lubrication stern shaft sealing apparatus may be determined according to product design standards and design parameters; usually an amount of static leakage of 0 is required; the amount of dynamic leakage of sealing apparatus may be determined according to product design standards and design parameters, and for water seals used in the front end of the stern tube of inland waterway ships, it is to be not more than 2 L/h;
- (2) Wastage: The wastage of all types of sealing apparatus is required to comply with the requirements for service life of the stern shaft sealing apparatus; it may be determined according to product design standard and design parameters; usually the following requirements are to be complied with at the least: the wastage of a sealing ring of soft material which operates for 100 h with clean water as the test medium is to be not more than 0.02 mm;
- (3) Reliability requirements: The MTBF of oil seals is to be not less than 6400 h; the service life is 3 ~ 5 years; the MTBF of the rubber ring type and gland box type water seals is to be not

less than 6400 h; the MTBF of the leaf spring type ones is to be not less than 3000 h; the MTBF of the cylindrical spring type ones is to be not less than 8000 h; the service life is 3 ~ 5 years;

7 Type approval

7.1 General: Until passing the type B approval, the apparatus will not be inspected and used on board;

7.2 Selection of typical sample for type approval

Products of each model are to be subject to type test for the first approval; for the series type approval of products of same model but different specification, one of the products most representative or of maximum size is to be selected for type test, and sampling quantity may be appropriately increased or combinations may be used to achieve effective coverage when the main technical data fail to be covered. The sample selected is to be a product with representative specification among the same model series, representative or inclusive of the product or series products to be approved in terms of the characteristic, feature and manufacturing quality; only one model most representative or with maximum market demand in each series is selected as the sample for re-approval.

7.3 The type approval test program is to be approved as per the requirement of working procedure of type approval, and the type approval test items are usually to include:

- (1) Physicochemical properties test of raw materials of main parts and components;
- (2) Water pressure test for strength of main pressure parts and components;
- (3) Visual inspection, structural dimension and machining accuracy inspection of main parts and components;
- (4) Static oil pressure test of stern shaft sealing apparatus;
- (5) Dynamic operation test of stern shaft sealing apparatus;
- (6) Endurance test;

7.4 Requirements for test equipment and condition of type approval

- (1) Test site: If the factory laboratory/test bench is taken as the test site of approval test, it is to be examined to the satisfaction of the Surveyor of CCS; otherwise, all tests are to be conducted in test organizations accepted by CCS.
- (2) Measuring instrument: The measuring instrument for test is to have the metrological calibration certificate which is within the period of validity, with an accuracy as specified in the table below:

Measuring instrument

Table 7.4

Item	Instrument	Accuracy
Pressure	Pointer pressure gauge or other pressure-measuring instruments	$\pm 1\%$
Temperature	Glass thermometer or other temperature-measuring instruments	$\pm 1^{\circ}\text{C}$
Revolution speed	Mechanical tachometer, photoelectric tachometer or other tachometers	$\pm 1\%$
Leakage amount	Measuring vessel	0.5 mL
Torque	Tacho-torquemeter or other measuring instruments	$\pm 1\%$
Wastage	Dial gauge (reading in 0.001 mm) (micrometer) or other measuring instruments	0.001 mm

- (3) Test equipment: The design of the test equipment is to comply with the usage, test condition and installation requirements of stern shaft sealing apparatus, and the test equipment is to be provided with air-vents; pressure stabilization measures are to be taken for static pressure and operation test and the pressure fluctuating value is to be within $\pm 5\%$ of specified value; the revolution speed tolerance of the shaft of test equipment is $+30 \sim -10\%$ of the specified value; the test equipment is to ensure a steady and uniform temperature inside the seal chamber. The temperature inside the seal chamber is to be kept within $\pm 10^{\circ}\text{C}$ of stipulated test temperature; suitable devices are to be provided for collecting and measuring all test medium leaked at the stern shaft seals; the dimension and machining accuracy of the associated installation position of stern shaft sealing apparatus, axial play and radial run-out of the revolving shaft and perpendicularity of the shaft to the end face of the seal chamber are to meet relevant provisions of plans and relevant product standards; the test bench is to have sufficient rigidity and robustness to prevent excessive vibration; sensing elements for measuring the temperature of test medium and sealing ring lip are to be installed properly;

7.5 Test method of type approval

- (1) Physicochemical properties test of raw materials of main parts and components:

- ① Materials such as rubber compound used in seals: The samples are selected from the same batch of material by the Surveyor and sent to test organizations accepted by CCS after sealed to conduct the physiochemical property test and ageing resistance test of rubber, and the test results are to comply with the design requirements;
- ② Important parts such as spring, seal seat body, end sealing cover, grip ring and shaft bush are to be subject to physiochemical property test of raw materials according to sampling;

- (2) Visual inspection, structural dimension and machining accuracy inspection of main parts and components:

- ① Castings such as seal housing, seal cover and grip ring are to be free of defects such as pore, slag inclusion, shrinkage, sand hole, scab, crack and scratch, and the structural dimension and working accuracy of main machining components are to be inspected according to plans approved by CCS and relevant standards;
 - ② The surface of spring is to be smooth without defects such as crack, wrinkle, burr, scale and corrosion, and the free length, the length under installation state and the radial force of spring are to be measured according to the requirements of plans approved by CCS; for multiple-spring mechanical seal, the difference in free heights of springs of the same seal is not more than 0.5 mm;
 - ③ The surface of seal is to be smooth and flat without defects such as pore, slag inclusion and crack, and the physicochemical properties, structural dimension and machining accuracy are to comply with the requirement of plans approved by CCS;
 - ④ The working surface of shaft bush and end sealing cover is to be free of cracks, shrinkages, porosity and any scars, and the surface roughness, plating thickness, structural dimension and machining accuracy after fine finishing are to comply with the requirements of plans approved by CCS;
 - ⑤ Defects such as burr, damage, deformation and corrosion are not permitted in other parts;
- (3) Water pressure test for strength of main pressure parts and components:
- For main pressure parts such as seal seat body, seal cover and shaft bush, the compressive strength test of outer housing is conducted with a pressure of 0.3 MPa for 0.5 h without leakage.
- (4) Static oil pressure test of oil lubrication stern shaft sealing apparatus;
- ① The stern shaft sealing apparatus is installed on the test bench; when the stern shaft is in a simulated state of no wear, the pressure in each oil chamber is increased to 1.25 times the design pressure (and not less than 0.2 MPa) and the pressure-holding time for static pressure test is not less than 15 min; the leakage amount of lubricating oil is tested and non-leakage is required;
 - ② The stern shaft sealing apparatus is installed on the test bench; when the stern shaft is in a simulated state of 2 mm wear, the pressure in each oil chamber is increased to 1.25 times the design pressure (and not less than 0.2 MPa); the leakage amount of lubricating oil is tested and non-leakage is required;
- (5) Dynamic operation test of oil lubrication stern shaft sealing apparatus: The operation test is mainly designed to check the assembly quality of stern shaft sealing apparatus and stern shaft, attention is to be paid to check whether the temperature of sealing ring lip at the stern shaft sealing apparatus and oil temperature and temperature rise inside the lubricating oil chamber are within the stipulated range, whether the leakage amount at the oil seal complies with the stipulated requirements, and whether there are any abnormal vibration, noise, etc.;

the dynamic operation tests are to be conducted under concentric state and under wear-down and eccentric state respectively:

- ① Test under concentric state: The stern shaft sealing apparatus as the subject of approval is installed on a special test bench. The shaft bush or dummy shaft is driven to operate at 25%, 50%, 75% and 100% of the maximum design linear velocity and finally to operate for 5 h at design linear velocity and design pressure (not lower than 0.2 MPa) with a lubricating oil temperature of 60°C; parameters such as leakage amount, linear velocity and temperature rise are measured every 1 h and the results are to comply with the design requirements of product.
- ② Test under wear-down and eccentric state: With an eccentricity of 2 mm, the stern shaft sealing apparatus as the subject of approval is installed on the special test bench and operates for 0.5 h at the maximum design linear velocity and design pressure (not lower than 0.2 MPa); parameters such as leakage amount, linear velocity and temperature rise are measured respectively and the results are to comply with the design requirements of product.

(6) Static oil pressure test of water lubrication stern shaft sealing apparatus;

- ① The stern shaft sealing apparatus is installed on the test bench; when the stern shaft is in a simulated state of no wear-down, after the compressed air of 1.5 times the design pressure is filled into air-tight tire, the pressure inside the water chamber of stern shaft sealing apparatus is increased to design pressure (not less than 0.2 MPa) and the pressure-holding time for static pressure test is not less than 15 min; the leakage amount of water is tested and non-leakage is required;
- ② The stern shaft sealing apparatus is installed on the test bench; when the stern shaft is in a simulated state of 2 mm wear-down, after the compressed air of 1.5 times the design pressure is filled into air-tight tire, the pressure inside the water chamber of stern shaft sealing apparatus is increased to design pressure (not less than 0.2 MPa) and the pressure-holding time for static pressure test is not less than 15 min; the leakage amount of water is tested and non-leakage is required;;

(7) Dynamic operation test of water lubrication stern shaft sealing apparatus: The operation test is mainly designed to check the assembly quality of stern shaft sealing apparatus and stern shaft, attention is to be paid to check whether the temperature of seals at the stern shaft sealing apparatus and water temperature and temperature rise inside the water chamber are within the stipulated range, whether the leakage amount at the water seal complies with the stipulated requirements, and whether there are any abnormal vibration, noise, and temperature rise, etc.; the dynamic operation tests are to be conducted under concentric state and under wear-down and eccentric state respectively:

- ① Test under concentric state: the stern shaft sealing apparatus proposed to be approved is installed on the special test bench. The shaft bush or dummy shaft is driven to operate at 25%, 50%, 75% and 100% of the maximum design linear velocity and finally to operate for 3 h at design linear velocity and design pressure (not lower than 0.2 MPa); parameters such as leakage amount, linear velocity and temperature rise are measured every 1 h and

the results are to comply with the design requirements of product.

- ② Test under wear and eccentric state: With an eccentricity of 2 mm, the stern shaft sealing apparatus as the subject of approval is installed on the special test bench and operates for 0.5 h at the maximum design linear velocity and design pressure (not lower than 0.2 MPa); parameters such as leakage amount, linear velocity and temperature rise are measured respectively and the results are to comply with the design requirements of product.
- (8) 5000-hour endurance test and teardown inspection after test: The shaft bush or dummy shaft is driven to operate at 25%, 50%, 75% and 100% of the maximum design linear velocity and finally to operate for 5000 h at design linear velocity and design pressure (not lower than 0.2 MPa) with a lubrication and cooling medium temperature of 60°C, and parameters such as test pressure, temperature, revolution speed and amount of leakage are measured and recorded every four hours and any failures are not to occur during the 5000-hour endurance test; the stern shaft sealing apparatus is stopped for teardown inspection after 5000 hours, and there is to be no sign of over-wear on its moving sealing face; the wastage of sealing pair measured is to comply with the requirements for service life of stern shaft sealing apparatus, the measured dimensions of sealing apparatus before and after test are provided and the structural dimension and tolerance clearance of parts are still to meet the requirements.

8 Unit/batch inspection

8.1 The application for CCS product inspection is permitted only for those stern shaft sealing apparatuses which have passed CCS type approval and the manufacturer's inspection/test and proven to be deliverable: so attention is to be paid during the inspection and evaluation of products to check whether the type of stern shaft sealing apparatus as the subject of application has passed type approval;

8.2 Inspection items are to be conducted according to the inspection program approved at the time of approval and usually inclusive of specified material inspection, visual inspection, structural type and dimension inspection, water pressure test of pressed parts and static leakage test of sealing apparatus;

8.3 The above tests may be carried out one by one independently by the manufacturer, with a complete test report to be submitted to the Surveyor for review; when applying for product inspection, the applicants are to submit *Raw Material Quality Certificate Document of Main Parts and Components*, *Water Pressure Test Records for Strength of Pressure Parts* and *Static Leakage Test Records of Sealing Apparatus* of the batch to the CCS Surveyor for approval.

8.4 On-site inspection:

The stern shaft sealing apparatus as the subject of inspection are to be visually inspected on site in the factory one by one by the Surveyor; materials and supply channel of important parts and components in stern shaft sealing apparatus are examined according to the approval plans and supplier's list agreed at the time of approval; at least 4% (or 1 unit) of each batch/model of stern shaft sealing apparatus are sampled randomly for re-test of "static leakage test" or subject to

on-site test witness at the manufacturer's premises;