Guideline No.H-02(201610)

H-02

HYDRAULIC CYLINDER

Issued date: October 28, 2016

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.

Historical versions and release date: H-02（201510）October 20, 2015

Main changes:

The “5 material and components” is amended to coordinate with the rules.

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HYDRAULIC CYLINDER

1 Application

1.1 Unless otherwise stated by CCS, this Guideline applies to hydraulic cylinders installed on hydraulic systems and devices for essential equipment of CCS classified ships, using the hydraulic oil or other mineral oil with equivalent performance as the working medium. It mainly applies to hydraulic cylinders for hydraulic steering gear, davits and lifting appliance luffing mechanism and may be provided as a reference for hydraulic cylinders used for other equipment.

1.2 This Guideline only involves routine selections of and requirements for design strength and materials for intended purposes of hydraulic cylinders. The designer and purchaser of hydraulic cylinders are to be responsible for specific adaptability to, conformity with, etc. hydraulic devices which are to be related to the rationality of design parameter selection, accuracy of structural dimension selection, etc. of hydraulic cylinders.

1.3 This Guideline mainly involves the following hydraulic cylinders:

(1) Piston type hydraulic cylinder;

(2) Plunger type hydraulic cylinder;

(3) Rotary vane type hydraulic cylinder.

1.4 Valves and electrical control devices (e.g. isolating valve, equilibrium valve, servo valve, proportional valve, stroke detection & feedback device and stepping motor etc.) matched with hydraulic cylinders are to comply with relevant requirements of CCS Rules and corresponding product inspection guidelines (including marine environmental condition test requirements).

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 the Construction of Inland Waterways Steel Ships*

(3) *CCS Rules for Materials and Welding*

(4) *CCS Rules for Lifting Appliances of Ships and Offshore Installations*

(5) *International Convention for the Safety of Life At Sea, 1974 and its amendments (hereinafter referred to as "SOLAS")*

(6) *International Life-Saving Appliance Code (LSA) and its amendments*

2.2 The above bases for approval and inspection contain provisions which, through reference in this Guideline, constitute provisions of this Guideline. For the dated references, all the subsequent amendment lists (excluding the content of corrigendum) or revisions do not apply to this Guideline; therefore, the latest editions of these documents are to be complied with during the product design, manufacturing and inspection. For the undated references, the latest editions apply

to this Guideline.

3 Terms and definitions

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

3.2 The following definitions are added in this Guideline:

(1) Nominal pressure

It is the nominal value of working pressure of the hydraulic cylinder and is generally considered to be equivalent to the required "design pressure" or "maximum permissible working pressure" of CCS Rules. It is a kind of working pressure that can ensure the design life during continuous operation under the specified condition.

(2) Breakaway pressure

It is the minimum pressure for hydraulic cylinder startup.

(3) Theoretical force

It is a force applied to the effective area of the piston or plunger, i.e. multiply the oil pressure by the effective area of the piston, plunger or moving vane.

(4) Actual force

It is a push or pull force actually output by the hydraulic cylinder.

(5) Load efficiency

It is the ratio of the actual force to theoretical force of hydraulic cylinder, represented in percentage.

4 Plans and documents

4.1 In the first application for hydraulic cylinder product approval and case-by-case product examination, the following plans and technical documents conforming to the design requirements of this Guideline shall be submitted:

(1) General assembly plan which is generally to be indicated clearly:

① Main configurations and dimensions, which are generally to be indicated clearly: Piston/piston rod/plunger diameter, inner and outer diameters of hydraulic cylinder block, hydraulic cylinder stroke, angle of rotary vane type hydraulic cylinder, installation dimension, seal setting, internal mechanical locking mechanism, damping device, oil-pipe-burst-proof device (schematic diagram to be provided if applicable), etc.;

② Material specifications and designations of main parts (including reference standards), mainly including the specification, model and strength grade of main stressed bolts;

③ Technical requirements related to manufacturing and inspection, which are to define

applicable technical standards, specifications or design base of the product;

④ Main technical parameters of the hydraulic cylinder, including the design pressure (nominal pressure) (MPa), design temperature range (in compliance with the requirements for minimum and maximum operating ambient temperature), recommended model of applicable working medium (hydraulic oil) and intended purpose and special installation requirement of the product;

⑤ Theoretical or actual push/pull force of the hydraulic cylinder – stroke load characteristic (if applicable);

⑥ Special operation requirements (if applicable), e.g. whether there are unbalanced load and lateral force and whether there is a need to bear additional supporting force or tension.

(2) Plans of the following parts (if applicable):

① Piston type hydraulic cylinder: Cylinder block, end cover/eye, piston, piston rod, lug, ring key, hydraulic cylinder base, etc.;

② Plunger type hydraulic cylinder: Cylinder block, plunger, plunger pin, hydraulic cylinder base, etc.;

③ Rotary vane type hydraulic cylinder: Cylinder block, end cover, fixed vane, moving vane, rotor, etc.;

④ Other plans, including plans of sheaves, hinge pins, etc. for the pushing hydraulic cylinder with sheaves and necessary plans of the hydraulic cylinder with an internal positioning & locking device or digital hydraulic cylinder requested by CCS as needed.

Where the cylinder, piston rod, etc., adopt the welding machining process, the structural plan of each welded joint, nondestructive test requirement, etc. are to be stated clearly.

(3) Manufacturer's product type approval test program (if applicable), which is to state the following content explicitly:

① Test items and acceptable criterion;

② Test methods (if applicable);

③ Requirements for test instrument (if applicable);

④ Requirements for testing environmental condition (if applicable);

⑤ Requirements for testing medium (oil) (if applicable);

⑥ Requirements for testing loading equipment (if applicable), etc.

(4) Calculation book, which is generally to include the following content:

① Cylinder strength;

② Hydraulic cylinder compression bar stability (buckling) check; (if applicable)

③ Thread connection strength calculation;

④ Welding strength calculation;

⑤ Ring key strength calculation.

(5) Product Instructions (as needed), which is generally to include the following content:

① Specifications and standards met by the product design and product scope;

② Main technical parameters of the product (including the recommended working medium);

③ Product installation and maintenance requirements;

④ Necessary safety warnings;

⑤ Emergency troubleshooting.

(6) Physicochemical property data sheet of materials of main parts (if non-standard or non-GB-specified materials are used).

4.2 In the first application for product approval and inspection, manufacturer is to directly submit the documents of main product manufacturing processes (casting, forging, welding, heat treatment, nondestructive test, product traceability rules, etc.) (if applicable) CCS to local Branch/Office of CCS in the area of the manufacturer.

5 Materials and components

5.1 Materials and components are to be controlled according to relevant requirements of the CCS Rules currently in effect;

5.2 The hydraulic cylinder is generally to comprise the following materials and components:

(1) Piston type hydraulic cylinder: Generally including the cylinder block, piston, piston rod, lug, ring key, important seal, base (if applicable);

(2) Plunger type hydraulic cylinder: Generally including the cylinder block, plunger, important seal, plunger pin and base (if applicable);

(3) Rotary vane type hydraulic cylinder: Generally including the cylinder block, end cover, fixed vane, important seal, moving vane and rotor.

6 Manufacturing process control

6.1 The welding process of the following important welded structural parts of the hydraulic cylinder is to be evaluated according to the CCS welding procedures and comply with the relevant requirements of Part Three of CCS *Rules for Materials and Welding* prior to manufacturing:

(1) Welding of such important structures as cylinder block and end cover, cylinder block and

hinged shaft, cylinder block and end connection as well as piston rod and lug;

(2) Parts directly transferring the force of the hydraulic cylinder: e.g. plunger, piston rod, end connection, rotor of the rotary vane type hydraulic cylinder.

7 Design and technical requirements

7.1 Dimension

(1) For the plunger diameter of the plunger type hydraulic cylinder, the piston rod diameter, cylinder block inner diameter and area ratio of cylinder block inner diameter to piston rod diameter of the piston type hydraulic cylinder, etc., priority is to be given to compliance with the requirements for dimension series of relevant standards.

(2) The designer is to ensure that the dimension of the oil inlet/outlet of the hydraulic cylinder is not less than the installation dimension of the standard oil port flange and pipe joint in nominal pressure grade of the hydraulic cylinder.

(3) The designer is to ensure that the stroke or angle, installation dimension, oil inlet/outlet type, oil port position and direction, damping device setting, etc. of the hydraulic cylinder meet the requirements of the orderer or design plans.

7.2 Appearance and machining qualities

The manufacturer is to ensure that the appearance and machining qualities of the parts meet the requirements of plans and relevant standards.

7.3 Materials

(1) All parts contacting with the working medium (e.g. hydraulic oil) of the hydraulic cylinder are to be made of non-erosive materials not reacting with the working medium;

(2) The working medium (e.g. hydraulic oil) recommended by the designer for the hydraulic cylinder is to have good chemical stability and viscosity-temperature property and meet the requirements for operation in an intended environment;

(3) Unless otherwise stated, the components playing a major role in the hydraulic cylinder (e.g. cylinder block, plunger, piston, piston rod, moving/fixed vane, rotor, end connection and hinged shaft) are generally to be made of steels or other ductile metallic materials and meet the requirements of officially published national and international material standards. The material elongation of a finished component is generally not to be less than 12%, and a set of the three specimens is to be provided, and the average impact energy of the material's Charpy V-notch impact test is not to be lower than 27J under the following temperature conditions. The material inspection and test are to meet the requirements for corresponding material type of CCS *Rules for Materials and Welding* or the standard approved by CCS. Cold-drawn tubes are to be used after stress removal.

① Unless otherwise stated, the material's Charpy V-notch impact test temperature of the hydraulic cylinder intended to be used on the ship deck is to be - 20℃; 35# and 45# (GB/T699) quality carbon structural steels are generally unsuitable to be used as the welded structural parts of the hydraulic cylinder with a design temperature lower than -

19 ℃;

② Unless otherwise stated, the material's Charpy V-notch impact test temperature of the hydraulic cylinder intended to be used in an enclosed compartment of the ship is to be the normal temperature (20 ℃);

③ Where the design temperature of the hydraulic cylinder is lower than - 25 ℃, the standard material's Charpy V-notch impact test temperature is to be the minimum design temperature of the hydraulic cylinder.

(4) Unless specially approved by CCS, the plunger, piston rod and hinge pin are not to be made of casting materials. If hinged shafts are matched with the hydraulic cylinder, they are to be made of solid forgings while small ones may be made of rolled plates;

(5) The formed steel tubes for the cylinder are generally to meet the relevant requirements of Section 2, Chapter 4, Part One of CCS Rules for Materials and Welding or the standard approved by CCS. The manufacturer is to sample the incoming tubes in each furnace batch number purchased from the material manufacturer not works approved by CCS for re-test of physicochemical properties of materials in which the Surveyor of CCS may participate if necessary;

(6) The materials of lifting movable parts such as the pin are also to be selected in accordance with the requirements of CCS *Rules for Lifting Appliances of Ships and Offshore Installations*;

(7) The adaptability to intended operation and storage environments is to be taken into consideration for the selection of material and product protection/corrosion prevention measures of the hydraulic cylinder, e.g. salt corrosion problems, etc. are to be considered, and the thickness, hardness, chromeplating process, etc. of the chromeplating layer forming a movable sealing face with a seal are to meet the requirements of relevant standards.

7.4 Structural design

(1) With regard to the structural design of the hydraulic cylinder, the designer is to fully consider the working safety and reliability and adaptability to the operation environment (e.g. condition of operation environment, inclination and swaying, shock and vibration). Depending on different intended purposes, the special operation requirements for intended matched relevant hydraulic systems and devices of the CCS Rules as well as the applicable requirements of CCS *Guidelines for Inspection of Hydraulic Power Devices* are to be met;

(2) Unless the designer provides sufficient evidence including the installation, support and stress conditions of the hydraulic cylinder on the equipment, the effect of additional bending moment on the plunger or piston rod, etc. to demonstrate that a non-radial spherical plain bearing can also meet the intended purpose, a radial spherical plain bearing (spherical hinge) is generally to be used for the hydraulic cylinder with a single lug set on its end;

(3) In addition to the radial spherical plain bearing described in Article 7.4(2), a shaft sleeve is to be set in the lug hinge pin hole. The guide sleeve, bearing, shaft sleeve, etc. of the piston, piston rod or plunger are generally to be made of metal. But the guide sleeve (ring) and

shaft sleeve are generally not to be made of common grey cast iron or nodular cast iron except the bearing. For the guide sleeve (ring), bearing and shaft sleeve made of nonmetal, the designer is to provide sufficient evidence to demonstrate that the technology is mature, the material performance is stable and controllable and the intended purpose can be met, e.g. permissible specific pressure value, ageing resistance and linear thermal expansion coefficient;

(4) Unless standard or technically mature self-lubricating bearing materials are used and the designer is to provide sufficient evidence to demonstrate that the technology is mature, the material properties are stable and controllable and the intended purpose can be met, all bearings and shaft sleeves are to be set with effective lubricating devices;

(5) The designer is to take into account the effect of bending moment caused by the stressed piston rod lug during actual hydraulic cylinder operation and specially pay attention to the working reliability of connectors between the piston rod and the lug;

(6) For the hydraulic cylinder with sheaves, the designer is to provide the rope in-out stress directions as well as corresponding calculation and check to prove that the strength of hydraulic cylinder can meet the intended purpose. The configuration, material and dimension of sheaves are to meet the requirements for sheaves - a kind of lifting parts of CCS *Rules for Lifting Appliances of Ships and Offshore Installations*;

(7) The designer is to ensure that the thread-connected parts including the thread connectors between the piston rod and the piston/lug are provided with reliable anti-looseness measures;

(8) The designer is to take into account the possibility of facilitating the inspection and replacement of seals and sealing devices and give priority to the selection of seals which meet the standards at the time of component design;

(9) The manufacturer is to ensure that materials of seals (including the supporting ring) are resistant to corrosion of the working medium and intended environmental medium, have good ageing resistance and sealing performance, work reliably within the ranges of design temperature and pressure of the hydraulic cylinder and meet the intended purpose and provide the inspection or test report of seals and their materials if necessary;

(10) With regard to lifting hydraulic cylinders requiring supporting loads, e.g. hydraulic cylinders for lifting appliance luffing mechanism, hatch cover and elevator, V-shaped fabric rubber sealing rings or seals with similar performance are to be used as motive seals for oil cavities whose leakage causes weight drop;

(11) Seals of the hydraulic cylinder for the hydraulic steering gear are to be set in accordance with the applicable requirements of CCS *Guidelines for Inspection of Hydraulic Steering Gear*;

(12) The designer is to ensure that the setting mode, set position, groove type, dimension, surface roughness, etc. of seals (including the supporting ring) meet the requirements of standards or recommended by the seal manufacturer;

(13) The hydraulic cylinder is generally to be provided with a bleeder;

(14) The designer is to ensure that structures of components are so designed that local stress concentration is reduced as far as possible;

(15) The quantities of pressure-bearing oil port flange bolts and end cover bolts are not to be less than 4 and 6 respectively, and the thread engagement depth is generally not to be less than the bolt diameter;

(16) At least the following dimensions are generally to be adopted for the hydraulic cylinder lug:

Thickness of lug: 1.2 ~ 1.4 times the hinge pin hole diameter (small value for low pressure and great value for high pressure)

Outer edge radius *R* of lug (spherical radius *SR*): 1.4 times the hinge pin hole diameter when the radial spherical plain bearing is used; 1.2 times the hinge pin hole diameter when the shaft sleeve is used.

(17) The designer is to pay attention to the effect of overshoot pressure generated after the piston/plunger of the hydraulic cylinder equipped with a damping device enters the damping area on its relevant parts and reduce the pressure impact as far as possible;

(18) The welding face between the oil port flange base block or thread pipe joint base block and the cylinder block is to be processed that it is in line with the cylinder block appearance.

7.5 Welding

(1) Welding materials are generally to meet the requirements of Chapter 2, Part Three of CCS *Rules for Materials and Welding* or the standard approved by CCS;

(2) The strength of deposited metals at weld seams of main stressed structural parts is not to be lower than the strength of base metal;

(3) Unless otherwise stated, all components, subject to internal pressure, of the hydraulic cylinder all welded joints within the pressure boundary of the hydraulic cylinder are to be of full penetration type, and those of components transmitting mechanical loads are at least to have equivalent strength. The detailed welding plans (including the groove type and welding material), welding and heat treatment processes, etc. are to be approved by CCS;

(4) Unless otherwise stated by CCS, the welding, welding groove type, etc. of all components, subject to internal pressure, of the hydraulic cylinder are to meet the requirements of Chapter 7, Part Three of CCS *Rules for Materials and Welding* or the standard approved by CCS.

7.6 Nondestructive test

(1) The main stressed weld seams such as the weld seam of the hydraulic cylinder block and the weld of the lug and cylinder block end cover are to be subject to an overall nondestructive test, and the welding quality is to meet the requirements of the standard accepted by CCS;

(2) Unless otherwise stated by CCS, the main pressure-bearing and stressed parts such as the cast cylinder block, lug, cylinder bottom, end cover, moving and fixed vanes and rotor are to

be subject to 100% nondestructive test as per the test method and acceptable quality in compliance with the requirements of the standard accepted by CCS;

(3) The hinged shaft described in Article 7.3(4) of this Guideline is to be subject to 100% ultrasonic flaw detection and its quality is to meet the requirements of standard accepted by CCS.

7.7 Performance requirements and test methods

(1) No-load operation: The hydraulic cylinder (after air bleeding) is to be subject to full-stroke operation under the no-load condition for at least three times and is to stop at the limit end for 10 s. The hydraulic cylinder is to operate stably without abnormal vibration, creeping or other phenomena, the plunger or piston rod is to be free from oil-ring-shaped traces and the stroke (or angle of rotary vane type hydraulic cylinder) and installation dimension of the hydraulic cylinder are to meet the requirements of the plan design. The hydraulic cylinder with a damping device at its end is to be tested and run for additional number of times. The damping effect is to meet the design requirements when the piston moves to the end with a damping device at the maximum permissible design speed of the hydraulic cylinder;

(2) Breakaway pressure: The breakaway pressure (pressure difference of oil inlet and outlet) of the hydraulic cylinder under the no-load condition is to meet the requirements of the plan design or standard;

(3) Minimum steady operating speed: The oil return back pressure of the hydraulic cylinder having passed the hydraulic test is to be controlled below 0.5 MPa. The hydraulic cylinder is to be subject to full-stroke operation at the minimum steady operating speed in accordance with the requirements of the plan design or standard under the no-load condition for at least 2 times, without creeping or other abnormal phenomena;

(4) Hydraulic test:

Unless otherwise explicitly stated, all assembled hydraulic cylinders are to be subject to a hydraulic test under the test pressure equal to 1.5 times the nominal pressure prior to painting. Under the test pressure, the stress of cylinder block is not to exceed 90% of yield strength of its material at the test temperature when it is calculated according to the effective thickness.

Test methods: Keep the piston/vane of the tested hydraulic cylinder in two limit positions respectively (set the single-acting plunger type hydraulic cylinder in the stroke limit position), apply the required pressures for the hydraulic test to the working cavities respectively, maintain such pressures for 5 min and ensure all parts are free from damage or permanent deformation and the sealing gasket and weld seam are not leaky.

(5) Tightness test and internal leakage measuring: Unless otherwise explicitly stated by CCS, the assembled hydraulic cylinder is to be subject to a tightness test under the test pressure equal to 1.25 times the nominal pressure by reference to the test methods given in the hydraulic test and the faying faces of parts are to be free from external leakage. The internal leakage amounts between the cylinder barrel and the piston/rotary vane and between the moving vanes measured under the nominal pressure of the hydraulic cylinder are to meet the requirements of the plan design or standard;

(6) External leakage: The leakage amount of the hydraulic cylinder during piston rod, plunger or rotor operation is to meet the requirements of the plan design or standard at the same time when the hydraulic cylinder is subject to no-load operation, high/low temperature, hydraulic, tightness and durability tests;

(7) Load efficiency: Unless otherwise stated, the hydraulic cylinder selected to be the prototype is to be subject to a load efficiency test. Install the tension and pressure tester on the hydraulic cylinder piston rod/plunger (install the torductor on the rotor or use an equivalent method), run the tested hydraulic cylinder at a uniform speed, test the load efficiency under different working pressures and ensure it meets the requirements of the plan design or standard;

(8) High/low temperature test: Unless otherwise stated, the hydraulic cylinder selected to be the prototype is to be subject to a high/low temperature test. When the temperature of the hydraulic oil at the hydraulic cylinder inlet is equal to 90℃ or maximum design temperature (whichever is greater) and -15℃ or minimum design temperature (whichever is lesser), the hydraulic cylinder is to work continuously without external leakage in each faying face within 1 h operation at high temperature and run normally without such abnormal phenomena as seizure, vibration or creeping within 10 min operation at low temperature.

Dry heat test methods: Keep the temperature of the testing working medium at 90 ± 2℃ when the ambient temperature is 65 ± 5℃ and ensure the hydraulic cylinder is subject to continuous full-stroke back-and-forth operation for 1 h at a speed of 100 ~ 120 mm/s.

Low temperature test methods: Conduct heat preservation for 0.5 h at the ambient temperature of -25 ± 2℃ or at the minimum design temperature of the hydraulic cylinder (whichever is lesser), put in the working medium at - 15 ± 2℃ and ensure the hydraulic cylinder is subject to continuous full-stroke back-and-forth operation for 10 min at a speed of 100 ~ 120 mm/s (speed in the plan design of the rotary vane type hydraulic cylinder).

(9) Durability: Unless otherwise stated, the durability performance of the hydraulic cylinder selected to be the prototype is to meet the requirements of the plan design or standard. The tested hydraulic cylinder is to continuously operate at the maximum design speed as per the specified number of times under the nominal pressure for at least 8 h each time. During the test, the parts of the tested hydraulic cylinder are not to be adjusted;

(10) Additional test items for other specially designed hydraulic cylinders: The type test items and requirements for the hydraulic cylinder with an internal self-locking function and digital hydraulic cylinder are to be otherwise agreed based on the specific product design structure;

(11) Overhauling: The hydraulic cylinder is to be overhauled after the type test and its relevant parts are to be free from such abnormal phenomena as obvious abrasion and scratch. The manufacturer is to ensure that the testing medium is clean and the internal cleanness indicator of the hydraulic cylinder after the test meets the requirements of the standard accepted by CCS or of the orderer.

7.8 Marking

(1) The hydraulic cylinder is generally to be set with a permanent nameplate made of corrosion-resistant materials such as stainless steel and brass.

(2) The nameplate is at least to be sculptured or marked with the following content:

① Product name;

② Model;

③ Main technical parameters, e.g. nominal pressure, stroke (angle of internal mechanical limiter of rotary vane type hydraulic cylinder), plunger diameter of plunger type hydraulic cylinder or cylinder block inner diameter and piston rod diameter of piston type hydraulic cylinder;

④ Name or registered trademark of manufacturer;

⑤ Hydraulic cylinder serial number;

⑥ Product delivery or manufacturing date.

(3) The hydraulic cylinder proper (e.g. outer edge of flange) is to be marked with the serial number.

(4) The product instructions mentioned in Article 4.2 (2) and the nameplate in Article 7.8 (2) are to be provided in both Chinese and English, or may be in English only if the user is a non-Chinese ship owner.

7.9 Strength requirements

(1) Permissible stress

① To determine the dimensions of parts, the permissible stress is not to exceed the required value in Article 8.1 of CCS *Rules for Survey of Hydraulic Power Devices* unless otherwise required by this Guideline. The safety coefficients A and B are to meet the following requirements:

(a) The safety coefficients A and B are to be selected as per the corresponding requirements of relevant CCS Rules if any;

(b) The safety coefficients A and B of the cylinder, subject to internal pressure,(including cylinder flange bolt, end cover bolt, and the wall thicknesses of internal pressure-bearing plunger/piston rod) of the hydraulic cylinder are generally not to be less than the following values:

Safety coefficient A or B **Table 7.9 (1)**

Safety coefficient	(Forged or rolled) steel	Cast steel	Nodular cast iron
A	3.5	4	5
B	1.7	2	3

(c) The safety coefficients A and B of structural parts such as the piston rod/plunger, lug, fixed and moving vanes, rotor and hinged shaft of the hydraulic cylinder are generally

not to be less than the following values:

Non-cast metal material: A = 4.5;

Cast metal material: A = 6;

(d) The safety coefficients A and B of the cylinder, subject to internal pressure,(including cylinder flange bolt, end cover bolt, and the wall thicknesses of internal pressure-bearing plunger/piston rod) of the hydraulic cylinder for common marine hydraulic steering gear are to meet the requirements of Table 7.1 of this Guideline; those of the cylinder, subject to internal pressure,(including cylinder flange bolt, end cover bolt, and the wall thicknesses of internal pressure-bearing plunger/piston rod) of the hydraulic cylinder for a single set of important marine hydraulic steering gear which is to comply with the additional requirements of CCS *Rules for Classification of Sea-going Steel Ships* are to meet the requirements of Table 7.9 (2) of this Guideline:

Safety coefficient A or B **Table 7.9 (2)**

Safety coefficient	(Forged or rolled) steel	Cast steel	Nodular cast iron
A	4	4.6	5.8
B	2	2.3	3.5

(e) The permissible stress of structural parts such as the piston/ plunger, lug, moving and fixed vanes, rotor and hinge pin of the hydraulic cylinder for the hydraulic steering gear is to meet the following requirements:

With regard to the hydraulic cylinder for the hydraulic steering gear of a marine ship: it is to follow the relevant requirements of Paragraph 3, of 7.1(1) of CCS Guidelines for Inspection of Hydraulic Steering Gear, etc.;

With regard to the hydraulic cylinder for the hydraulic steering gear of an inland waterways ship: it is generally not to exceed 40% of yield strength of materials.

(f) The safety coefficients A of the hydraulic cylinder (including the fixed parts) for the davits and the movable parts such as pin are not to be less than 4.5 and 6 respectively.

(g) The safety coefficient or permissible stress of the lifting movable parts such as the pin is also to be selected in accordance with the requirements of CCS Rules for Lifting Appliances of Ships and Offshore Installations (if applicable).

② The safety coefficient or permissible stress of the hydraulic cylinder having a complex structure and form and requiring a finite element strength check is to be selected by reference to relevant standards or published design manuals. To verify the reliability of calculation and check, a burst test for the miniature model in compliance with similar theoretical requirements may be required by CCS if necessary. The minimum burst pressure Pb is to be calculated in accordance with the following requirements:

$$P_b = P\,A\,(R_{ma}/R_m) \quad \text{MPa}$$

Where: P_b — minimum burst pressure, in MPa;

P — nominal pressure (design pressure) of hydraulic cylinder, in MPa;

A — selected according to Article 7.9 (1) of this Guideline;

R_{ma} — actual tensile strength of cylinder block material, in N/mm^2;

R_m — minimum theoretical tensile strength of cylinder block material at the ambient temperature, in N/mm^2;

(2) In addition to the strength of the hydraulic cylinder and its parts explicitly required to be calculated by relevant CCS Rules, that of the hydraulic cylinder and its parts below is to be checked to be acceptable by the product designer (if applicable):

① Pressure-bearing cylinder block of hydraulic cylinder (including the internal pressure-bearing plunger/piston rod):

(a) Minimum wall thickness of cylinder block: It is to follow Article 1.1, Appendix 1, Chapter 6, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*, the permissible stress is to be selected by reference to Article 7.9 (1) of this Guideline, and the additional corrosion allowance may be 0.3 mm for hydraulic cylinders except that used for the hydraulic steering gear;

(b) Minimum wall thickness of cylinder block end cover: It is to follow Article 8, Appendix 1, Chapter 6, Part Three of *CCS Rules for Classification of Sea-going Steel Ships*, and the permissible stress is to be selected by reference to Article 8.1 of *CCS Guidelines for Inspection of Hydraulic Power Devices*;

(c) Connection strength of cylinder block and end cover, generally including thread or the keyway strength in case of ring key connection;

② Strength of piton rod/plunger, e.g. tensile/compressive strength of piston rod/plunger and strength of thread on both ends of piston rod or relief groove;

③ Strength of connecting bolts for end cover, end cover and flange, e.g. strength of blind flange bolt or screw;

④ Strength of fixed vane, e.g. bending strength and structural strength of connections for fixed vane and cylinder block;

⑤ Strength of moving vane, e.g. bending strength;

⑥ Rotor (shaft) strength, e.g. torsional strength and keyway strength;

⑦ Lug strength;

⑧ Strength of hinge pin and hinged shaft, e.g. bending strength and shearing strength;

⑨ Hydraulic cylinder compression bar stability/buckling check (if the ratio of the piston rod

diameter and the calculated piston rod length is greater than 10)

⑩ Other calculation and check concerning the working safety and reliability of the hydraulic cylinder, e.g. strength of parts with an internal self-locking function (if applicable), possibly including the capability of bearing a lateral load of the hydraulic cylinder, compressive strength of bearing bush and base strength as needed.

(3) The strength of flange bolts is to be checked in accordance with the requirements of Article 8.2 of CCS Guidelines for Inspection of Hydraulic Power Devices.

(4) The stress of parts is to be routinely checked in accordance with the requirements of Article 8.4 of CCS Guidelines for Inspection of Hydraulic Steering Gear or as per the published design manuals.

(5) The strength of the base bearing the upsetting moment and its fixing bolt group is to be checked in accordance with the requirements of Article 8.6 of CCS Guidelines for Inspection of Hydraulic Steering Gear or as per the published design manuals.

(6) When the main stressed structural parts are connected by means of thread and welding, the strength of weld seams is to be checked and accepted unless welding is only used for the purpose of looseness prevention which requires a thread strength check.

(7) When the strength of weld seams is checked, the strength coefficient is to be selected as per Table 6.2.6.1 of Part Three of CCS Rules for Classification of Sea-going Steel Ships.

(8) The hydraulic cylinder compression bar stability/buckling is to be checked in accordance with the requirements of Article 8.7 of CCS Guidelines for Inspection of Hydraulic Steering Gear or as per the published design manuals. The safety coefficient nk is to be 4. In case of fine calculation (by reference to the technical standard ISO/TS 13725), it may be less than 4 but is not to be less than 3.

(9) If the hydraulic cylinder is equipped with hydraulic pipelines prior to delivery, the wall thickness is to be checked in accordance with the requirements of Article 7.3.4 of CCS Guidelines for Inspection of Hydraulic Power Devices.

8 Selection of typical samples

8.1 Sampling principles of the prototype for type test:

(1) A prototype is to be the most representative hydraulic cylinder product in each series; it is featured by poorest load condition, worst compression bar stability condition, smallest safety allowance for the cylinder block and its main stressed parts, etc.

(2) The same “series” means products basically have the same configuration of cylinder block and its parts, material selection, sealing construction type and material, hydraulic cylinder installation type, guide sleeve/shaft sleeve type and material, intended purpose, etc.

(3) The prototype may be a miniature model in accordance with similar theoretical requirements and is to meet the following requirements when the hydraulic cylinder strength is calculated: similar boundary condition, similar stressing condition and structure and smallest safety coefficient allowance for the hydraulic cylinder, etc.; (a high pressure grade is to prevail)

If the manufacturer only applies for the approval or first inspection of single-sized products, one set may be randomly sampled for type test.

8.2 Hydraulic cylinder products after approval may be subject to unit/batch inspection set by set or as per such methods as combined sampling depending on the circumstances, which may be specifically implemented according to the *Inspection Plan* issued by CCS.

8.3 Hydraulic cylinder products which are not subject to works approval or type approval of CCS may be inspected set by set or as per such methods as combined sampling depending on the circumstances.

9 Type test

9.1 The following equipment (if applicable) is to be calibrated appropriately prior to the test:

(1) Pressure gauge or sensor;

(2) Tension and pressure tester or torque tester;

(3) Electronic testing or recording device.

The precision grade of testing instrument is to meet the requirements of the standard accepted by CCS, and the measuring range is to be in line with the tested parameter.

9.2 Samples are to be subject to the following inspections:

(1) Visual inspection: To comply with the requirements of Articles 7.1, 7.2 and 7.8 of this Guideline;

(2) Material inspection: To comply with the requirements of Articles 5 and 7.3 of this Guideline;

(3) Structural design inspection: To comply with the requirements of Article 7.4 of this Guideline;

(4) Inspection of welding and heat treatment processes: To comply with the requirements of Articles 6 and 7.5 of this Guideline;

(5) Nondestructive test: To comply with the requirements of Article 7.6 of this Guideline.

9.3 The type test is to comply with the requirements of Article 7.7 of this Guideline and is generally to include the following items:

(1) No-load operation, to comply with requirement of Article 7.7 (1) of this Guideline;

(2) Breakaway pressure, to comply with requirement of Article 7.7 (2) of this Guideline;

(3) Minimum steady speed, to comply with requirement of Article 7.7 (3) of this Guideline;

(4) Hydraulic test, to comply with requirement of Article 7.7 (4) of this Guideline;

(5) Tightness test and internal leakage measuring, to comply with requirement of Article 7.7 (5) of this Guideline;

(6) External leakage inspection, to comply with requirement of Article 7.7 (6) of this Guideline;

(7) Load efficiency of hydraulic cylinder, to comply with requirement of Article 7.7 (7) of this Guideline;

Mainly for:

① Required prototype for hydraulic cylinder type test;

② Hydraulic cylinder with explicit requirements for its load efficiency and force.

(8) High/low temperature test, to comply with requirement of Article 7.7 (8) of this Guideline;

Mainly for:

① Required prototype for hydraulic cylinder type test;

② Movable mating parts made of different materials for the first time and including non-metallic materials of the hydraulic cylinder (e.g. nylon bush and supporting ring)

③ Movable seals using new materials and structures.

(9) Durability test, to comply with requirement of Article 7.7(9) of this Guideline;

Mainly for:

① Required prototype for hydraulic cylinder type test;

② Newly-structured hydraulic cylinder under a poor load condition.

The unapproved products in the unit/batch inspection may be accepted in accordance with the requirements of the plan design and the orderer depending on the specific circumstances (e.g. intended purpose) and may also be subject to relevant test and verification after being matched with the system assembly.

(10) Additional test items of other specially-designed hydraulic cylinders (if applicable), to comply with the requirement of Article 7.7 (10) of this Guideline;

(11) Overhauling, to comply with the requirement of Article 7.7 (11) of this Guideline.

9.4 The viscosity of the testing hydraulic oil is to be the same as that of the hydraulic oil recommended to be used by users as far as possible. The data such as the testing hydraulic oil designation and temperature are to be recorded during the test.

10 Unit/batch inspection

10.1 Quality assurance

(1) The manufacturer is to ensure that the design, manufacturing, inspection and test of the hydraulic cylinder meet the performance characteristics of samples approved by CCS.

(2) The manufacturer is to assure the quality of the hydraulic cylinder designed, manufactured, inspected, tested and marked in accordance with the requirements of this Guideline and ensure and promise that the hydraulic cylinder meets the requirements of this Guideline. The hydraulic cylinder not in accordance with the requirements of this Guideline is not allowed to be publicized or sold through marks related to the inspection requirements of CCS.

10.2 Inspection

(1) The manufacturer is to submit all the necessary conditions and documents to the Surveyor to demonstrate compliance with this Guideline, which generally include:

① Material certificate of main parts;

② Seal document (if applicable);

③ Plans approved by CCS through examination and plan approval notice;

④ Factory inspection and test reports (inspection and test items in line with Articles 10.3 ~ 10.4);

⑤ Declaration of conformity or certificate (Refer to Article 10.1 for content).

10.3 Unless otherwise specially stated by CCS, the unit/batch inspection and test items of the hydraulic cylinder are generally to include the following content:

(1) Inspection items:

① Visual inspection: To comply with the requirements of Articles 7.1, 7.2 and 7.8 of this Guideline;

② Material inspection: To comply with the requirements of Articles 5 and 7.3 of this Guideline;

③ Structural design inspection: To comply with the requirements of Article 7.4 of this Guideline;

④ Inspection of welding and heat treatment processes: To comply with the requirements of Articles 6 and 7.5 of this Guideline;

⑤ Nondestructive test: To comply with the requirements of Article 7.6 of this Guideline.

(2) Test items:

① No-load operation: To comply with requirement of Article 7.7 (1) of this Guideline;

② Breakaway pressure: To comply with requirement of Article 7.7 (2) of this Guideline;

③ Minimum steady speed: To comply with requirement of Article 7.7 (3) of this Guideline;

④ Hydraulic test: To comply with requirement of Article 7.7 (4) of this Guideline;

⑤ Tightness test and internal leakage measuring: To comply with requirement of Article 7.7 (5) of this Guideline;

⑥ External leakage inspection: To comply with requirement of Article 7.7 (6) of this Guideline;

⑦ Additional test items of other specially-designed hydraulic cylinders (if applicable): To comply with the requirement of Article 7.7 (10) of this Guideline;

10.4 The manufacturer is also to complete the following product inspection items:

(1) Delivery inspection and test items which are designated by the manufacturer and specified in the explicit product design standards;

(2) Special test items added via the technical order contact (if applicable).

10.5 The manufacturer is required to inspect and test each hydraulic cylinder concerned for the above items, and apply for inspection to CCS after they have passed the inspection and test. The Surveyor is to perform the field sampling and inspection and test according to the proportion and items as specified in the Inspection Plan issued by CCS in conjunction with the Certificate of Approval.

10.6 The hydraulic cylinder is to be subject to necessary load and utility tests after being installed on hydraulic equipment or shipped (if the hydraulic cylinder assembly is not installed by the hydraulic equipment manufacturer) and is to be in accordance with the requirements of relevant rules of CCS and intended purposes.