Guideline No.: B-05(202511)

B-05

SEAMLESS STEEL GAS CYLINDERS

Issued date: November 01, 2025

Foreword

China Classification Society (hereinafter referred to as 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 service@ccs.org.cn .

Historical versions and release date: B05 (201510), October 20, 2015

B-05(201705), May 9, 2017

B-05(202211),November 15,2022

Main changes:

1. Add the test item ‘Bottom sealing test (only applicable to the bottom of cylinders made of steel pipes)’ into Table 7.2.

2. Text modification.

CONTENTS

SEAMLESS STEEL GAS CYLINDERS

1 Application

1.1 This guideline is applicable to the works approval and unit/path inspection of refillable seamless steel gas cylinders for ships which are used for containing compressed, liquefied and dissolved gases and for quenched and tempered steel cylinders with a maximum actual tensile strength of less than 1100 MPa, and with water capacities up to and including 450L, and a service environment temperature shall meet the requirements.

1.2 This guideline is not applicable to the seamless steel gas cylinders used for containing dissolved gases and adsorbed gases and cylinder pressure vessels mounted as accessory on transport vehicles and machinery installations. Seamless steel gas cylinders are not to be used for containing the media having stress corrosion tendency.

1.3 This guideline is in principle only applicable to the approval and unit/path inspection of the body of seamless steel gas cylinders, not for head valves.

1.4 This guideline is applicable to the seamless steel gas cylinders used on ships, Seamless steel gas cylinders for offshore installations and etc. can refer to this Guideline.

1.5 Upon the approval of CCS, seamless steel gas cylinders may be approved and unit/path inspected in accordance with the technical requirements of recognized standards.

1.6 Seamless steel gas cylinders for specific purposes shall comply with the requirements of relevant conventions, regulations, rules and relevant standards for specific purposes. For example, seamless steel gas cylinders for inflation systems of inflatable liferafts shall comply with the relevant requirements of the International Life-saving Appliance Code.

2 Normative references

Chapter 2, Part Six of China Classification Society Rules for Classification of Sea-going Steel Ships

ISO 9809-1:2019 Gas cylinders—Design, construction and testing of refillable seamless steel gas cylinders and tubes—Part 1: Quenched and tempered steel cylinders and tubes with tensile strength less than 1100 MPa.

3 Terms and definitions

3.1 For the purpose of this guideline, the following definitions are used:

(1) Hydraulic test pressure Ph: the pressure to be reached during hydraulic test.

(2) Yield strength: the upper yield strength is to be taken where the material test specimen exhibits apparent yielding during the tensile test; where the test specimen does not exhibit apparent yielding, the specified non-proportional elongation strength under the test force,

Rp0.2, is to be taken as the yield strength of the material.

(3) Batch quantity: the specified quantity of steel cylinders which adopt the same design conditions, have the same nominal diameter and design wall thickness, are made of steel of the same heat/furnace number by the same manufacturing process, and are continuously heat treated in accordance with the same heat treatment specifications. For quenched and tempered steel cylinders, a batch corresponds to a quantity of not less than 200 plus the number of steel cylinders used for destructive test.

(4) Filling ratio: the maximum allowable weight of gas to be filled per unit water capacity of the steel cylinder specified in the applicable standards for various filled media.

(5) Burst pressure Pb: the maximum pressure of gas cylinders reached during burst test.

4 Drawings and documentation

4.1 The following drawings and documentation to be submitted are to be submitted to CCS for approval:

(1) Seamless steel gas cylinder drawings. Drawings are to reflect the products' structural form, main dimensions, materials, mechanical and chemical parameters, manufacturing and heat treatment methods, nominal working pressure, hydraulic test pressure and other special technical requirements;

(2) Seamless steel gas cylinder design calculations. Relevant calculations, including strength calculations of cylinder body, base and head, are to be made in accordance with the design standard;

(3) Type test plan.

4.2 The following drawings and documentation to be submitted are to be submitted for review when the initial works approval is being applied for:

(1) Basic information of the manufacturer: name, address and production history of the manufacturer, types and specifications of current products, the types, specifications and delivery conditions of the products for which approval is being applied, information on other certification or qualification certificates obtained, etc.;

(2) Quality system documents and other management documents. The organizations of the quality system and product quality control points are to be clearly defined in these documents;

(3) Main production, measuring/testing equipment.

List of main production equipment:

Forming equipment;

Heat treatment furnace's type, dimensions, heating method, temperature controlling and recording method, and arrangement of temperature measuring points.

List of main measuring/testing equipment

List of equipment for chemical components analysis, mechanical properties, mechanical test, metallographic test, NDT, hydraulic test, etc. (including the product name, type, manufacturer, statutory inspection organization and valid period of verification/calibration)

(4) Process documents:

Production process flow chart (quality control points are to be indicated);

Operation guidance books with various work procedures indicated in production process flow chart, including the main work procedures such as forming, heat treatment, NDT, etc.;

(5) Qualification certificates of testing and inspection personnel;

(6) Test location and laboratory qualifications (where the test is subcontracted, the qualification of the subcontractor and subcontract agreement are to be described).

(7) List of suppliers of materials and main parts;

(8) Product description and quality certificates (sample).

5 Technical requirements

5.1 General design requirements

5.1.1 The design formula used to determine the wall thickness of cylinder body is to comply with the requirements of recognized standards (e.g. ISO 9809-1).

5.1.2 The guarantee value of the yield strength of heat treated material, R_{eg}, is to be taken for design of wall thickness of parts under pressure, and the limit of the ratio of yield strength guarantee value R_{eg} to tensile strength guarantee value R_{mg} is to comply with the requirements of the standards;

5.1.3 The design and calculation of the wall thickness of the bottle body shall be subject to the hydrostatic test pressure P_h; the hydraulic test pressure of the cylinder is 1.5 times of the nominal working pressure

5.1.4 In general, more than two openings on a gas cylinder are not allowed, and the openings can only be designed to be arranged along the neutral axis of the gas cylinder.

5.1.5 For CrMo steel, the actual maximum tensile strength of cylinder body material Rma is generally not to exceed 1100MPa; for CMn steel, the actual maximum tensile strength Rma is not to exceed1030MPa. For cylinders filled with the medium posing a risk of hydrogen embrittlement, the actual maximum tensile strength of cylinder body material Rma is generally not to exceed

880MPa, or may not exceed 950Mpa when the actual yield-strength ratio is not more than 0.9.

5.1.6 The bottom structure of seamless steel cylinders is to comply with the following requirements:

(1) The structural form and dimensions are to comply with the requirements of relevant standards;

(2) The part in connection to convex base is to be smooth and its thickness is to be no less than the design thickness of the cylinder body;

(3) There is to be a transitional section between the annulated shell of concave base and the cylinder body. The connection of transitional section to cylinder body is to be smooth.

(4) The design of convex base and concave base is to be subject to fatigue test by means of cyclic pressurization. The design of cylinder bases is considered qualified provided that the cylinder bases can withstand 80000 cycles of pressurization with the upper limit of cyclic pressure being at the nominal working pressure, or 12000 cycles of pressurization with the upper limit of cyclic pressure being at the test pressure, Or for cylinders with a hydraulic test pressure p_h＞450 bar, the upper cyclic pressure may be reduced to two thirds of this test pressure. In this case, the cylinders shall withstand 80 000 cycles without being damaged, the design is not to be adopted if the cylinder bases have not passed the said test successfully.

5.1.7 The thickness of steel cylinder opening is to be measured in order to ensure that the opening will not be deformed when subject to the moment of valve-tightening force couple and the additional external force of neck ring riveting.

5.1.8 The internal threads of cylinder openings are to comply with the following requirements:

(1) The thread are to comply with the requirements of recognized standards.

(2) The number of useful ordinary threads is to be such that the shear safety factor calculated at the hydraulic test pressure of steel cylinder, Ph, is at least 10, and no less than 6.

5.2 General requirements for manufacturing

5.2.1 The manufacture of marine seamless steel gas cylinders, inspections/tests upon completion are to comply with the requirements of CCS Rules for Classification of Sea-going Steel Ships, approved drawings and relevant standards.

5.2.2 The manufacturers of marine seamless steel gas cylinders are to introduce the manufacturing process, describe the manufacturing tools having significant impact on product quality such as the press head for air cylinder pressing and drawing, mold plate or mold tool for shell nosing during rotary pressing or mold pressing, and specify other requirements for process verification before the product is put into service, regular inspection, repair and replacement when the product is in service, etc.

5.2.3 The cylinder body is not allowed to be welded or repaired. The crack, inclusion, non fusion and other defects on the inner surface of the cylinder from the tube shall be removed by mechanical milling and other methods. The treatment of surface defects of the cylinder body shall comply with the requirements of relevant recognized standards for gas cylinders.

5.3 The filling ratio is to be consistent with the strength of cylinder body and also comply with the requirements of the conventions, regulations, rules and recognized standards involved in the use of gas cylinders.

6 Materials and components

6.1 The material used for the manufacture of gas cylinders shall be steel, other than rimming quality, with non-ageing properties and shall be fully killed with aluminium and/or silicon. In cases where examination of this non-ageing property is required by the customer, the criteria by which it is to be specified should be agreed with the customer and inserted in the order.

6.2 The material of cylinder body is to be compatible with the gas intended to be filled. Refer to ISO 11114-1 for compatibility of cylinder material with the gas;

6.3 The S element content (mass fraction) of the cylinder body material obtained through heat analysis is not to exceed 0.010% and the P element content (mass fraction) thereof obtained through heat analysis is not to exceed 0.020%. And the sum of S+P content percentages is not to exceed 0.025%;

6.4 The limit values (the difference between the maximum content and the minimum content) of the chemical composition of cylinder body material are not to exceed the values listed in the table 6.4 below:

Chemical Composition Table **Table 6.4**

Element	Maximum content (mass fraction), %	Limit value (mass fraction), %
C	<0.30	0.06
	≥0.30	0.07
Mn	--	0.30
Si	--	0.30
Cr*	<1.50	0.30
	≥1.50	0.50
Ni*	--	0.40
Mo*	--	0.15

Notes: ① The requirements in the table above must be complied with where the element marked by "*" are alloy elements of the steel;

② The maximum content of any intentionally added element is to be reported;

③ Total content of V+Ni+Ti+B+Zr is not to exceed 0.15%.

6.5 The cylinder body is generally to be manufactured with nationally or internationally recognized steel used for cylinders . Typical recognized steels include CrMo steel and CMn steel.

6.6 Rough rolled billets or steel billets are to be subject to macrostructure examination and defects such as flakers, residual shrinkage cavity, delamination, air bubble, foreign matters and impurity inclusion are not allowed. The center porosity is to be no greater than grade 1.5 and segregation no greater than grade 2.5. For seamless steel pipes, the wall thickness deviation is not to exceed -10%~+15% of the nominal wall thickness and the steel pipes are to be 100% satisfied by UT.

7 Type test

7.1 Sampling principle of type test

7.1.1 Seamless steel cylinders are to be type tested according to different types. Cylinders are considered to be of different types in any one of the following cases:

(1) Production process flow is different;

(2) Material designation is different;

(3) Heat treatment process is different;

(4) Structural form of cylinder bottom and ratio of bottom thickness to cylinder diameter are different;

(5) The overall length of the cylinder has increased by more than 50 % (cylinders with a length/diameter ratio less than 3 shall not be used as reference cylinders for any new design with this ratio greater than 3);

(6) The outside diameter or minimum guarantee thickness of the cylinder is different;

(7)The hydraulic test pressure is different (the design on the same basis with only hydraulic test pressure being reduced is not to be considered as new design);

(8) The minimum guaranteed yield strength and/or minimum guaranteed tensile strength are different.

(9) In case of tapered threads the torque test shall be performed; in case of parallel threads the calculation of the shear strength shall be performed, if the diameter of the internal thread has increased by 50% or more, the pressure cycling test on two cylinders shall also be performed.

7.1.2 For each type of gas cylinders for which approval is to be applied, at least 50 gas cylinders are to be manufactured by the applicant and tested in accordance with the corresponding requirements of the table in 7.2.

7.1.3 For marine seamless steel gas cylinders for type test, the acceptance of raw materials, main manufacturing process, inspection and test, and transfer of relevant marks must be carried out under the supervision of the surveyor and the results thereof are to comply with the requirements of CCS Rules for Classification of Sea-going Steel Ships and approved drawings.

7.2 Type test items and requirements

Type test items and requirements **Table 7.2**

Test item	Test quantity	Test requirements
Raw material inspection	Each heat or each batch	1. Each batch of raw materials are to be furnished with product quality certificates; 2. Elements to be analyzed are to include C, Si, Mn, P, S, Nb, V, Ti, Cr, Ni, Mo, Cu, Al, B, Zr, and purposefully added elements; 3. For seamless steel pipes, visual inspection, wall thickness inspection;
Internal and external visual inspection of gas cylinders	Each cylinder	The internal and external surfaces of finished gas cylinders are free of defects that may affect the safe use of gas cylinders, for details, see 8.3 of ISO9809-1:2019.
Inspection of dimension, shape and position tolerances, neck threads inspection	Each cylinder	1. Dimensional inspection: For each cylinder for type test, wall thickness, outer diameter and height of cylinder body, thickness and central depth (applicable to concave base) of cylinder base are to be measured. The results are to be consistent with the requirements of 7.3~7.6, 8.1, 8.2 of ISO 9809-1:2019 and CCS approved drawings. The thickness and outer diameter of the two cylinders for mechanical property test shall also be measured according to 7.3 to 7.6, 8.1 and 8.2 of ISO9809-1:2019 and the approved drawings, for each steel cylinder, three cross sections, namely the upper, middle and lower cross sections, are to be taken along the length of cylinder body. The wall thickness and outer diameter are to be measured respectively. Wall thickness of each cross section is to be measured at four measuring points evenly distributed along the circumference. The outer diameter is to be measured for two times vertically and crosswise. The thickness of cylinder base is to be measured at one measuring point located in the center of the base. For concave base, the thickness of the earthing point is also to be measured at the four measuring points evenly distributed along the circumference. The wall thickness measured at various points is to be no less than the minimum thickness guarantee value. 2. Form and position tolerances are to comply with the requirements of 8.5~8.9 of ISO 9809-1:2019. 3. Neck threads inspection shall conform to the requirements of 8.9 of ISO9809-1:2019.

Test item	Test quantity	Test requirements
Hardness test	Each cylinder	Hardness is to be tested at three points respectively located in the upper, middle and lower portions of the cylinder body and the results are to be consistent with the requirements of 11.3 of ISO 9809-1:2019 and approved drawings.
Ultrasonic test	Each cylinder	To be in accordance with 8.4 of ISO9809-1:2019 or relevant recognized standards.
Magnetic particle inspection (when applicable)	Each cylinder	If required by the standards that adopted, the results shall conform to the requirements of the standards.

Tensile test	2 cylinders to be taken randomly	1 test pieces/cylinder	To be in accordance with 10.2 of ISO 9809-1:2019 and approved drawings.
Bending or flattening test		Bending: 2 test pieces/ cylinder, flattening/ring flattening: 1 test piece / cylinder	To be in accordance with 9.2.4 of ISO 9809-1:2019.
Impact test		1 group 3 test pieces/ cylinder	To be in accordance with 10.3 of ISO9809-1:2019 and approved drawings.
Base check		1 test piece/cylinder	To be in accordance with 9.2.3 of ISO 9809-1:2019.
Hydraulic burst test	2 cylinders to be taken randomly		To be in accordance with 10.4 of ISO 9809-1:2019.
Pressure cycling test	3 cylinders to be taken randomly		To be in accordance with 9.2.2 of ISO 9809-1:2019.
Hydraulic test and Capacity check	Each cylinder		To be in accordance with 11.2, 11.5 of ISO 9809-1:2019.
Neck ring torque test (when applicable)	1 cylinder to be taken randomly		To be in accordance with 7.8 of ISO 9809-1:2019.
Torque test for taper thread only	1 cylinder to be taken randomly		To be in accordance with 9.2.5 of ISO 9809-1:2019.
Bottom sealing test (only applicable to the bottom of cylinders made of steel pipes)	Each cylinder		An appropriate test device is used to pressurize the central area of the inner surface of the bottom of the cylinder, The pressurized area should be at least 1/16 of the bottom area of the cylinder, and the diameter of the pressurized area should be at least 20mm.,The test medium can be clean air or nitrogen. The test pressure is the nominal working pressure of the cylinder, and the holding time is not less than 1min. The test area at the bottom of the cylinder is submerged in water and there shall be no leakage. This test can be replaced by an overall air tightness test.

Test item	Test quantity	Test requirements
Air tightness test (when applicable)	Each cylinder	If required by the approved standards, the results shall conform to the requirements of relevant recognized standards.

8 Unit/batch inspection

8.1 Generally, unit/batch inspection of marine seamless steel gas cylinders is to be carried out after works approval, the unit/batch inspection of unapproved seamless steel gas cylinders is to be carried out according to the requirements for type test of this guideline.

8.2 The unit/batch inspection (see 3.1 (6) for the definition of batch quantity) of seamless steel gas cylinders after CCS approval is to be carried out in accordance with the product inspection plan already approved during the approval. The test items listed in the table 8.2 are to be included:

Type test items and requirements **Table 8.2**

Test item	Test quantity	
Raw material inspection	Each heat or each batch	
Internal and external visual inspection of cylinder	Each cylinder	
Inspection of dimension, shape and position tolerances, neck threads inspection	Each cylinder	
Hardness test (at 1 measuring point on the cylinder body)	Each cylinder	
Ultrasonic test	Each cylinder	
Tensile test	1 cylinder/batch	1 time
Bending or flattening test (when applicable)		Bending:2 times Flattening/ring flattening:1 time
Impact test		1 group 3 times
Burst test	1 cylinder/batch	
Hydraulic test and Capacity check	Random inspection	
Dissection test of cylinder base (when applicable)	1 cylinder/batch	
Bottom sealing test (only applicable to the bottom of cylinders made of steel pipes)	Each cylinder	
Air tightness test (when applicable)	Each cylinder	
Other inspections (when applicable)	The test items required by drawings approved by CCS, approved standards or technical documents of the factory.	

Notes: ① The tests are to be carried out in accordance with the type test requirements specified in 7.2;

(a) Tensile test: 2 samples shall be taken when the drawings approved by CCS, approved standards or

technical documents of the factory require taking 2 samples;

(b) Impact test: for thin-walled transverse impact specimen with wall thickness less than 3.5 mm, flattening test is allowed to replace impact test;

(c) Ultrasonic testing: magnetic particle testing can be used to replace ultrasonic testing if the approved standards allow;

(d) Bottom tightness test: it can be replaced by air tightness test or helium leak test.

(e) "When applicable": bending test or flattening test, cylinder bottom dissection test, air tightness test: tests shall be conducted when required by CCS approved drawings, approved standards or factory technical documents.

② Where the test results are not satisfactory, disposal is to be made according to the following provisions:

a. Where the non-conformity results from abnormal testing operation, noncompliance of test specimen preparationor measurement error, specimens of the same quantity may be re-tested; where the results of such re-test are satismanufacturer, the initial test will be invalidated;

b. Where a non-conformity due to heat treatment is confirmed, re-conducting the heat treatment to this batch of cylinders is allowable; however, the heat treatment is not be repeated for more than twice; for cylinder bodies which have been heat treated again, the design wall thickness is to be guaranteed; the batch of cylinder bodies which have been heat treated again are to be treated as a new batch for single batch inspection;

c. Where the non-conformity results from other causes, the non-conforming steel cylinders are to be discarded or repaired by approved means; the repaired steel cylinders are to be re-tested for the original non-conforming items.

8.3 Cylinders qualified through inspection are to be clearly identified with permanent marks according to relevant standards, and including CCS certificate No.and CCS steel stamp.

8.4 The product certificates will be issued for qualified products by CCS surveyor upon completion of product inspection.