



Guideline No. T-02(202502)

T-02

Process Pressure Vessels of Marine Alternative Fuel

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Foreword

The product inspection guideline of China Classification Society (hereinafter referred to as "CCS") specifies the applicable technical requirements and inspection and test requirements for classification products and authorized statutory products of ships to be approved/inspected by CCS.

The Guidelines allow users to adopt alternative test methods and requirements, provided they meet or exceed the standards set by the Guidelines.

The Guidelines are prepared and updated by CCS and published on <http://www.ccs.org.cn>. In case of any comments and suggestions, please contact CCS via service@ccs.org.cn.

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Process pressure vessels of Marine Alternative Fuel

1 Scope of Application

1.1 The Guidelines are applicable to pressure vessels used for processing of natural gas, ammonia and methanol cargo operating systems and fuel supply systems.

1.2 The Guidelines are not applicable to pressure vessels other than those used for processing as mentioned above.

1.3 The Guidelines do not cover requirements for heat exchangers.

1.4 The Guidelines are only applicable to the pressure vessel body, and does not include the requirements for thermal insulation layer.

2 Normative References

2.1 *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*

2.2 *CCS Rules for Natural Gas Fuel Used in Ships*

2.3 *CCS Rules for Classification of Sea-going Steel Ships*

2.4 *CCS Rules for Materials and Welding*

2.5 *CCS Guidelines for Ships Using Methanol/Ethanol Fuel*

2.6 *CCS Guidelines for Ships Using Ammonia Fuel*

3 Terms and Definitions

The terms and definitions defined in the above survey basis are applicable to the Guidelines. For the convenience of preparation and use, the following definitions are directly quoted or supplemented in the Guidelines.

Pressure vessel: a container and its accessories subject to external or internal

pressure.

Process pressure vessel: a pressure vessel used to store or treat liquid or vapour cargo.

4 Drawings and Data

4.1 During product drawing approval, the following drawings and data shall be submitted to CCS for approval:

- (1) List of product main performance specifications (including model and specification);
- (2) General assembly drawing (including structural drawings of body and component connection, accessory layout);
- (3) Drawings of main parts and components (including cylinder shell, end plate, welding structure drawing);
- (4) Strength and safety valve diameter calculations;
- (5) List of physical and chemical properties of materials for main pressure parts (not required if it has been reflected in the drawings);
- (6) Heat treatment process (if applicable);
- (7) Product instructions and nameplates;

4.2 For work approval, in addition to the drawings and data mentioned in 4.1 above, the following drawings and data shall be also submitted for approval:

- (1) Factory overview: factory name, address, production history, production capacity, technical and inspection personnel, main products, affiliation, product trademarks, etc.;
- (2) Details of the product to be approved;

- (3) List of main production equipment, including forming equipment, welding equipment, heat treatment equipment, cleaning and passivation equipment (if applicable);
- (4) List of main testing equipment, including the equipment for physical and chemical property tests of materials, nondestructive testing (NDT) equipment, pressure test equipment;
- (5) Main production process of the product to be approved;
- (6) Quality management documents or quality system certificates;
- (7) Enterprise registration certificate;
- (8) Qualification certificate and/or production license, including special equipment manufacturing license;
- (9) Product quality certificate or sample of certificate;
- (10) Quality control plan, if applicable;
- (11) List of qualified suppliers;
- (12) Approval type test program.

5 Technical Requirements

5.1 Design and manufacturing requirements

5.1.1 The structural design, accessory arrangement, strength calculation, manufacturing process of pressure vessels used for processing shall comply with CCS rules, the approved drawings and relevant recognized standards.

5.1.2 The main welds of process pressure vessels should generally be butt welds. Full penetration is generally required for stressed T-joints. Double-sided continuous fillet welds shall generally be used for stub pipes, flanges and base plates on the pressure shell.

5.1.3 For the components of process pressure vessels, their connections shall meet the requirements in 6.2.10, Chapter 6, Part 3 of *CCS Rules for Classification of Sea-Going Steel Ships*.

5.1.4 Process pressure vessels shall be provided with manholes to allow for internal inspection and cleaning. Pressure vessels which are too small to allow access for internal inspection shall be provided with an adequate number of inspection openings for internal inspection and cleaning.

5.1.5 The welding strength coefficient of pressure vessels for LNG processing shall be selected according to the relevant provisions in 4.23.2.1.3, Chapter 4, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and in 4.2.15.2③, Chapter 4 of *CCS Rules for Natural Gas Fuel Used in Ships*. The welding strength coefficient of pressure vessels for liquid ammonia processing shall be selected according to the relevant provisions in 4.23.2.1.3, Chapter 4, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*. The welding strength coefficient of pressure vessels for methanol processing shall be selected according to the relevant provisions in 6.2.6, Chapter 6, Part 3 of *CCS Rules for Classification of Sea-going Steel Ships*.

5.2 Selection of materials

5.2.1 The materials of pressure vessels for natural gas processing shall meet the relevant provisions of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and *CCS Rules for Natural Gas Fuel Used in Ships*. To use any materials other than those specified above, the detailed data of the materials shall be submitted to CCS for prior approval.

5.2.2 The materials of pressure vessels for ammonia processing shall be selected with consideration given to the corrosivity of the medium and the suitability for maximum working pressure and temperature. Materials susceptible to ammonia corrosion shall not be used, such as copper, copper-containing alloy, zinc, zinc-containing alloy, cadmium-containing and mercury-containing materials. The materials shall be selected according to *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and *CCS Guidelines for Ships Using Ammonia Fuel*.

5.2.3 The materials of pressure vessels for methanol processing shall be selected with consideration given to the corrosivity and swelling property of the medium. Materials sensitive to methanol shall not be used, such as metallic aluminum alloy, galvanized steel, lead alloy, non-metallic nitrile rubber, butyl rubber. The materials shall be selected according to CCS *Guidelines for Ships Using Methanol/Ethanol Fuel* and CCS *Rules for Materials and Welding*.

5.3 Heat treatment

5.3.1 Post-weld heat treatment

- (1) The requirements for post-weld heat treatment (PWHT) of process pressure vessels shall conform to CCS rules and relevant recognized standards. The heat treatment temperature, holding time, and heating and cooling rates should be carefully selected to effectively eliminate residual stress in the pressure shell and enhance its overall performance.
- (2) Generally, heat treatment can be exempted for the weld joints of austenitic stainless steel, duplex stainless steel and high manganese austenitic steel.
- (3) Pressure vessels for ammonia processing, if made of carbon-manganese steel or nickel steel, shall undergo PWHT to relieve stress.
- (4) If PWHT is required, test samples shall be prepared for heat treatment of base material to verify whether the performance of the base material after heat treatment meets the requirements of CCS rules.

5.3.2 Heat treatment for recovery performance of formed pressure parts

- (1) The cylinder and end plate of the cold-pressed process pressure vessel shall be subject to stress-relief heat treatment which can be carried out simultaneously with PWHT. If the ratio of inner diameter to wall thickness of cylinder is greater than or equal to 20, stress-relief heat treatment may not be necessary.
- (2) The components of process pressure vessels and formed through hot

working shall be normalized if the hot working is not completed within the normalizing temperature range. The alloy steel components should also be tempered as needed.

5.4 Welding procedure qualification

5.4.1 The welding procedure qualification shall be carried out under the supervision of the CCS surveyor when the process pressure vessel is manufactured for the first time or a new welding procedure is used.

5.4.2 The welding procedure qualification of pressure vessels for natural gas processing shall be carried out according to the relevant requirements in 6.5.3 and 6.5.4, Chapter 6, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and in 13.3.3 and 13.3.4, Chapter 13 of *CCS Rules for Natural Gas Fuel Used in Ships*.

5.4.3 The welding procedure qualification of pressure vessels for ammonia processing shall be carried out according to the relevant requirements in 6.5.3 and 6.5.4, Chapter 6, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*.

5.4.4 The welding procedure qualification of pressure vessels for methanol processing shall be carried out according to the relevant requirements in Chapter 3, Part 3 of *CCS Rules for Materials and Welding*.

5.4.5 For the welding procedure qualification of pressure vessels for ammonia processing, low-strength welding consumables shall be used as far as possible on the premise of meeting the strength requirements. All welds shall be subject to welding procedure qualification, including butt welding, repair welding, tube-to-tube plate welding, build up welding and fillet welding. Hardness of weld joints, including the weld, heat affected zone (HAZ) and base material, shall be determined. After PWHT, the hardness shall not exceed 220HV for carbon-manganese steel or shall not exceed 245HV for nickel steel.

5.5 Defect rectification

5.5.1 The scope of defects shall be determined if unallowable defects are

identified in the NDT of welds. Unallowable defects must be removed, and MT or PT can be used for detection if necessary. Repair welding shall be carried out only after defects are completely removed as required.

5.5.2 Repair welding procedure shall be reported to CCS for prior approval.

5.5.3 Defect rectification and repair welding shall be completed prior to PWHT. Generally, the same position allows weld defect rectifications twice at most.

6 Raw Materials, Parts and Components

6.1 Raw materials used in manufacturing of process pressure vessels, such as steel plates, steel pipes, pipe fittings, end plates, forgings and valves (when applicable), shall have the product certificates or equivalent documents from CCS. Raw materials used in manufacturing of process pressure vessels, e.g., welding consumables, shall have certificates of approval from CCS.

6.2 When steel plates or other raw materials cannot meet the certification requirements, quality control can be realized through re-inspection of raw materials under the supervision of the CCS surveyor. The inspection shall meet the relevant requirements of CCS rules.

7 Type Test

7.1 Selection of typical samples

The products used for the type test must be completed under the supervision of the surveyor in accordance with the welding procedure and drawings approved by CCS. They shall represent or cover the scope of the products to be approved in terms of characteristics, features and manufacturing quality (samples can be selected based on factors such as main material, design pressure, design temperature, wall thickness, outer diameter and volume).

7.2 Inspection of raw materials

7.2.1 The certificates and inspection basis of main materials, parts and components shall be checked for their compliance with CCS rules and approved

drawings and for the consistency between certificates and material marks. If raw materials are re-inspected, the test items and results of raw materials shall meet the requirements of CCS rules.

7.2.2 The selected welding consumables shall be compatible with the base material. Unless otherwise approved, they shall be low hydrogen or ultra-low hydrogen welding consumables. Before use, they shall be dried as required.

7.3 Welding inspection

7.3.1 The welding inspection shall at least cover the main butt welds, full penetration T-joints and other main welds of pressure vessels, including pre-welding inspection, welding inspection and post-welding inspection.

7.3.2 In pre-welding inspection, it is required to confirm that the weld groove, chamfering length, weld misalignment and butt gap meet the requirements of CCS rules, and drawings and welding procedure specifications approved by CCS. The surface within an area of at least 25mm from the groove and welding edge shall be free from oxides, moisture, oil stains and other contaminants that may affect the welding quality.

7.3.3 The welding shall be carried out in strict accordance with CCS rules and welding procedure specifications approved by CCS. The product manufacturer shall record the main parameters such as current and voltage during welding for review of the CCS surveyor.

7.3.4 After welding, the appearance quality of welds shall be inspected. The weld surface of pressure shell shall be uniform and compact without defects such as cracks, overlaps, pores, slag inclusions, undercuts, arc craters or incomplete filling. The above defects, if any, shall be removed before NDT. Weld misalignment, weld reinforcement and throat height shall conform to CCS rules or relevant recognized standards.

7.4 Product welding test

7.4.1 Process pressure vessels shall be subject to a product welding test during production. The method, process and heat treatment used for the product welding test sample shall be the same as those used for the pressure vessel cylinder. If heat

treatment is required, the test sample shall be heat treated together with the pressure vessel.

7.4.2 The sampling quantity, frequency and position of product welding test plate of pressure vessels for natural gas processing shall meet the requirements in 6.5.5, Chapter 6, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and in 13.3.5, Chapter 13 of *CCS Rules for Natural Gas Fuel Used in Ships*.

7.4.3 The sampling quantity, frequency and position of product welding test plate of pressure vessels for ammonia processing shall meet the requirements in 6.5.5, Chapter 6, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*.

7.4.4 The sampling quantity, frequency and position of product welding test plate of pressure vessels for methanol processing shall meet the requirements in Chapter 7, Part 3 of *CCS Rules for Materials and Welding*.

7.4.5 The product welding test items mainly include cross-weld tensile tests, longitudinal tensile test of weld, bending test, impact test and macroscopic inspection of weld section (if necessary). The sampling position, test requirements and results of samples shall conform to CCS rules mentioned above. Special attention shall be paid to the differences among rules mentioned above.

7.4.6 The product weld test of pressure vessels for ammonia processing shall also include hardness test, as detailed in 5.4.5 of the Guidelines.

7.5 NDT of welds

7.5.1 The welds of process pressure vessels shall undergo the NDT. The testing method, quantity and position shall meet the requirements of applicable CCS rules. The prior approval for NDT process shall be obtained from CCS.

7.5.2 The scope and method for NDT of welds of pressure vessels for natural gas processing shall meet the requirements in 5.9.3, Chapter 5 and 6.5.6, Chapter 6 of Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and in 13.6.3 and 13.3.6, Chapter 13 of *CCS Rules for Natural Gas Fuel Used in*

Ships.

7.5.3 The scope and method for NDT of welds of pressure vessels for ammonia processing shall meet the requirements in 5.9.3, Chapter 5 and 6.5.6, Chapter 6 of Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*.

7.5.4 The scope and method for NDT of welds of pressure vessels for methanol processing shall meet the requirements in 3.2.5.2, Chapter 3 of *CCS Guidelines for Ships Using Methanol/Ethanol Fuel* and in 7.5.4, Chapter 7, Part 3 of *CCS Rules for Materials and Welding*.

7.5.5 NDT procedures and acceptance criteria can be implemented according to recognized standards. NDT results shall generally be in accordance with the NDT evaluation standards specified on the approved drawings. If the design drawings do not specify NDT evaluation standards, NDT shall meet the requirements for testing technology class and acceptance level specified in Table 7.5.5 or equivalent standards.

Table 7.5.5 Qualification Indexes of NDT

Testing Method	Applicable Standards	Testing Technology Class	Qualification Level
Radiographic testing	NB/T47013.2	AB	II
Ultrasonic testing	NB/T47013.3	B	I
Magnetic particle testing	NB/T 47013.4	—	I
Penetrant testing	NB/T 47013.5	—	I

7.5.6 For the NDT of welds, the influencing factors of delayed cracking shall be taken into account. The NDT shall be carried out at least 24 hours after welding for materials prone to delayed cracking, and an additional NDT is required after heat treatment for materials prone to reheat cracking. The NDT shall be carried out 48 hours after welding for high-strength steel with a yield strength of greater than 395N/mm².

7.6 Pressure test

7.6.1 Each process pressure vessel shall undergo a pressure test, generally a hydraulic test after manufacturing.

7.6.2 Pressure Test of Pressure Vessels for Natural Gas and Ammonia Processing

- (1) The pressure test of pressure vessels for natural gas processing shall meet the requirements in 4.23.6, Chapter 4, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* and in 13.5.4, Chapter 13 of *CCS Rules for Natural Gas Fuel Used in Ships*. The pressure test of pressure vessels for ammonia processing shall meet the requirements in 4.23.6, Chapter 4, Part 3 of *CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*.
- (2) Generally, a hydrostatic test shall be carried out. During the test, the pressure measured at the top of the pressure vessel shall not be less than 1.5 times the design pressure (P_0). To ensure compliance with the above conditions, if the calculated main diaphragm stress exceeds 75% of the yield strength, it shall be monitored by strain gauges or other suitable devices during prototype test, except for simple cylindrical or spherical pressure vessels. In the pressure test, the pressure should be maintained for 2h per 25mm of plate thickness, but in no case less than 2h.
- (3) The pneumatic pressure test is permitted only when the design of the vessel or its supporting structure does not permit it to be safely filled with water, or dried, and when the vessel is used in a manner that does not allow traces of the test medium to remain in the vessel.

7.6.3 The pressure test of pressure vessels for methanol processing shall meet the requirements in 6.6.2, Chapter 6, Part 3 of *CCS Rules for Classification of Sea-going Steel Ships*. The test pressure shall not be less than 1.5 times the design pressure (P_0), and the holding time shall generally not be less than 30 minutes.

7.6.4 After the pressure test, in addition to visual testing, important positions of the process pressure vessel shall also undergo magnetic particle testing or penetrant testing. The position and quantity to be tested shall be approved by the surveyor.

7.7 Tightness test

7.7.1 After the hydrostatic test of process pressure vessels, each process pressure vessel and its related accessories shall undergo the tightness test to verify whether the vessel pipelines and its accessories are well sealed. They are deemed qualified if no leakage occurs during the test. The tightness test can be carried out simultaneously with the pressure test described in 7.6 of the Guidelines.

7.7.2 The medium for adequate tightness test (if used) can be dry and clean air, nitrogen or other inert gases. The adequate tightness test pressure shall meet the requirements of the drawings approved by CCS and relevant recognized standards. Generally, it shall be the design pressure (P0). During the adequate tightness test, the pressure shall be increased slowly to the test pressure which shall then be kept for a sufficient duration, e.g., 30 minutes. All welds and seals shall be checked with soapy water, and they shall be free from leakage.

7.8 Visual and dimension inspection

7.8.1 After the pressure vessel is manufactured, its surface shall be checked to ensure no scars on the shell surface.

7.8.2 The main dimensions of the pressure vessel, such as out-of-roundness and main dimensions of cylinder, shall meet the requirements of *CCS Rules for Materials and Welding*, drawings approved by CCS and relevant recognized standards.

7.8.3 The weld surface quality shall meet the requirements in 7.3.4 of the Guidelines.

8 Unit/Batch Inspection

8.1 The unit/batch inspection required to issue product certificates of process pressure vessels shall be carried out after the manufacturer obtains factory approval, unless otherwise specially stated. Each process pressure vessel shall undergo the unit/batch inspection.

8.2 The unit/batch inspection approved by CCS shall be carried out according to the product inspection plan approved at the time of approval. Specifically, the

following test items shall be included:

- (1) Inspection of raw materials;
- (2) Dimension and visual inspection;
- (3) Welding inspection: pre-welding inspection, welding inspection and weld appearance inspection;
- (4) NDT;
- (5) Product welding test;
- (6) Pressure test;
- (7) Tightness test;
- (8) Other tests (if applicable).