Guideline No. T-01(202502)

T-01

Type-C Independent Tank of Marine Liquefied Gas Fuel

Issued date: February 1, 2025

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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Main modifications in this version: None

Contents

Type-C Independent Tank of Marine Liquefied Gas Fuel

1 Application

1.1 The Guidelines are applicable to:

1.1.1 Independent steel welded Type-C tanks on steel ships using natural gas and ammonia as fuel, specified in the *Rules for Ships Using Natural Gas Fuels* and the *Guidelines for Ships Using Ammonia Fuel* of China Classification Society (CCS); and

1.1.2 Type-C independent liquid cargo tanks for carrying LNG and ammonia in bulk.

1.2 The Guidelines are not applicable to vacuum-insulated LNG tanks and LNG tank-containers.

2 Normative References

(1) CCS *Rules for Classification of Sea-going Steel Ships*

(2) CCS *Rules for Materials and Welding*

(3) CCS *Rules for Ships Using Natural Gas Fuels*

(4) CCS *Guidelines for Ships Using Ammonia Fuel*

(5) CCS *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*

(6) CCS *Guidelines for Survey of Liquefied Gas Carriers*

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.

The Type-C independent tank of marine liquefied gas fuel (hereinafter referred to as Type-C tank): a type of marine liquefied gas fuel containment system, which refers

to a self-supporting fuel tank that does not form a part of the hull structure and is not essential to the hull strength.

δ PWHT: weld joint thickness or post-weld heat treatment (PWHT) thickness.

4 Drawings and Documents

4.1 The following drawings and data shall be submitted to CCS for approval:

(1) General layout of Type-C tank;

(2) Basic structural drawing: including tank/tank body, fixed/movable saddle, lifting lug, liquid collecting well, anti-floating device; main component drawing: such as head, dome, liquid collecting well/submersible pump (borehole pump) seat, reinforcing/reinforced structure, wash bulkhead, vacuum ring, manhole, pipeline, stairway;

(3) Calculation: strength calculation of pressure-bearing components, sloshing analysis report, buckling analysis report, lifting lug strength calculation, safety valve displacement calculation, saddle strength calculation, strength calculation of anti-displacement/anti-floating components, thermodynamic calculation, load calculation of cold box connected with the tank, etc.;

(4) List of physical and chemical properties of materials for main pressure parts: plates, pipes and accessories, forgings, thermal insulation materials, etc.;

(5) Layout of laminated timber;

(6) Fatigue stress analysis report (if applicable);

(7) Overall stress analysis report of tank;

(8) Other required documents (filling/gas supply system diagram, etc.).

(9) Drawings and data as required in "Pipeline" in 1.2.1 (3), Section 2, Chapter 1 of the *Guidelines for Ships Using Ammonia Fuel*;

(10) Thermal stress analysis report of pipelines with design temperature lower than -110°C (if applicable) and temperature field analysis (if applicable);

(11) Description of thermal insulation arrangement for cryogenic pipeline (if applicable);

(12) Relevant risk analysis reports (e.g., ammonia engine risk analysis (like Failure Modes and Effects Analysis (FMEA) report).

4.2 The manufacture intending to obtain the initial works approval from CCS should submit the following drawings and documents 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: type, specification and technical characteristics of existing products; type, specification and technical characteristics of the product to be approved;

(3) Main production equipment and main inspection/test equipment:

① List of main production equipment: forming equipment, welding equipment, heat treatment equipment, cleaning and passivation equipment, etc.;

② List of main inspection/test equipment: list of test equipment for physical and chemical properties of materials, NDT equipment, pressure gauges and other equipment (including name, model and validity period of verification/calibration);

③ Load-bearing site or platform for hydraulic test.

(4) Main production process of the product to be approved:

① Production process flow chart (quality control points shall be marked) or inspection and test plan;

② Production process flow chart or operation instructions for each procedure in the inspection and test plan, including main procedures such as material acceptance, welding, heat treatment (if any) and NDT;

③ Process documents shall include: plate blanking, cutting and hoisting process, manufacturing of various sample plates, sample bars or sample boxes, head flap pressing process, construction process of main large components (heads and shell rings), welding procedure specifications or welding instructions, NDT plan, hydraulic test procedure, tightness test procedure and thermal insulation construction manual.

(5) Main management documents or quality system certificates; quality system documents and other management documents, in which the organization of the quality system and product quality control points shall be clearly indicated;

(6) Enterprise registration certificate;

(7) Qualification certificate and/or production license, obtained special equipment manufacturing license and other certification qualification certificates, if applicable;

(8) Qualification certificates of testers, surveyors and welders;

(9) Qualifications of the test site and laboratory (in case of subcontracting, qualifications of the subcontractor and subcontract agreement shall be explained);

(10) List of suppliers of materials and main components;

(11) Product quality certificate or sample of certificate, and product nameplate style;

(12) Approval type test program.

5 Technical Requirements

5.1 General requirements

5.1.1 The design and technical requirements of Type-C tanks shall conform to CCS *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, the *Guidelines for Ships Using Ammonia Fuel*, and pressure vessel standards recognized by CCS.

5.1.2 A Type-C tank shall be equipped with at least two sets/groups of pressure relief valves (PRVs), one of which can be disconnected in case of failure or leakage.

5.1.3 For Type-C tanks, the loading limit shall not exceed 95%, and the filling limit shall not exceed 98%.

5.1.4 Except for Type-C tanks which are designed to withstand the maximum vapor gauge pressure of the fuel at the highest design ambient temperature, their pressure and temperature shall be maintained within the design range by methods acceptable to the CCS, such as one of the following:

(1) Re-liquefaction of vapor;

(2) Thermal oxidation of vapor;

(3) Pressure accumulation;

(4) Cooling of liquefied gas fuel.

The selected method should be able to maintain the fuel tank pressure below the set pressure of the Type-C tank pressure relief valve for 15 days, assuming that the tank is fully loaded at normal working pressure and in the idling condition of the ship (i.e., supplying only power to domestic loads).

5.1.5 The pressure relief system, fuel tank loading limit, and maintenance of fuel storage conditions for Type-C tanks shall meet the requirements in Sections 5, 6 and 7, Chapter 4 of CCS *Rules for Ships Using Natural Gas Fuels* or in Sections 2, 3 and 4, Chapter 4 of the *Guidelines for Ships Using Ammonia Fuel*.

5.2 Material and pipeline design, manufacturing, connection details

5.2.1 Metallic materials used in the construction of LNG Type-C tanks shall meet the requirements in Chapter 6, Part 3 of CCS *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.* For non-metallic materials, please see Appendix 1 of the same CCS Rules for specific requirements.

5.2.2 Pipelines, valves, accessories and other equipment in contact with ammonia shall not be made of materials susceptible to ammonia corrosion such as copper, copper-containing alloy, zinc, zinc-containing alloy, cadmium-containing and mercury-containing materials. Gaskets and seals shall be made of metal, rubber, polymer and other materials compatible with ammonia, such as spiral wound gasket and PTFE. PWHT or welding procedure with hardness not greater than 185HB shall be used for welding. Nickel steels containing more than 5 % nickel shall not be used as materials in the construction of containers and pipeline systems intended to carry such goods. Nickel steels containing not more than 5% nickel may be used when the transportation temperature is best maintained close to the boiling point of the cargo at -33°C, but not exceeding -20°C.

5.2.3 All longitudinal and circumferential welds of the shell shall be in the form of butt, full penetration, double-sided V-groove or single-sided V-groove. For fully penetrated butt welds, double-sided welding or backing shall be used. The backing, if used, shall be removed after welding. Based on the results of welding procedure approval tests, other groove forms may also be used. The bevel groove for connecting joints between liquid cargo hold body and dome and between dome and related accessories shall be designed in accordance with standards accepted by the competent authority. Welds attaching nozzles, domes or other penetrations on vessels and all welds joining flanges to vessels or nozzles shall be of the full penetration type. With the consent of CCS, full penetration T (cruciform weld joint) weld connections may be used for Y-joints between the shell and longitudinal bulkheads (2 sloping internal bulkheads are also included in three-cylinder tanks) of double-cylinder and three-cylinder tanks.

5.2.4 The pipeline design, manufacturing and connection details shall meet the requirements in Chapter 3 of CCS *Rules for Ships Using Natural Gas Fuels* or Chapter 3 of the *Guidelines for Ships Using Ammonia Fuel*.

5.3 Heat treatment

5.3.1 Integral heat treatment should generally be preferred if PWHT is required for a Type-C tank due to design, construction material or contained medium. If integral heat treatment is not feasible due to certain constraints, segmented heat treatment may be permitted. However, it is essential to ensure that the entire length of the weld receives heat treatment.

5.3.2 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.

5.3.3 For independent Type-C tanks made of carbon steel or carbon-manganese steel, the heat treatment temperature and holding time to relieve residual internal stress are recommended to be as specified in Table 5.3.3. For alloy steels, the heat treatment process must be determined based on the selected material, and prior approval from CCS shall be obtained.

Table 5.3.3 Heat Treatment Temperature and Holding Time for Relieving Residual Stress

Steel Grade	Temperature (°C)	Time (h)
360, 410, 460, 490	580~620	1 h per 25 mm of thickness, but at least 1 h.

5.3.4 The PWHT in furnace can be carried out according to the following requirements:

(1) The PWHT operations for non-alloy steel and low-alloy steel shall meet the following requirements:

① The temperature in the furnace shall not be higher than 400°C when the weldment is put into the furnace;

② After the weldment is heated to 400°C, the temperature rise rate in the heating area shall not exceed 5500/δPWHT°C/h and shall not be higher than 220°C/h or lower than 15°C/h;

③ During temperature rise, the temperature difference within any length

of 4600mm in the heating area shall not exceed 140°C;

④ During heat preservation, the difference between the highest and lowest temperatures in the heating area should not exceed 80°C;

⑤ When the furnace temperature is higher than 400°C, the temperature drop rate in the heating area shall be 7000/δPWHT°C/h, and shall not be higher than 280°C/h or lower than 15°C/h;

⑥ The furnace temperature shall not be higher than 400°C when the weldment is removed from the furnace. After removal, it shall continue to cool in the air;

⑦ In segmented heat treatment, the repeated heating length shall not be less than 1500mm, and thermal insulation measures shall be taken for adjacent parts to ensure that the temperature gradient does not adversely affect the residual stress relief, deformation, or performance of the workpiece.

(2) Heat treatment operations for other materials shall meet the requirements in standards recognized by CCS.

5.3.5 LNG Type-C tanks:

The necessity of PWHT shall be determined based on the materials used in LNG Type-C tanks. If PWHT is required, the heat treatment process shall be approved by CCS.

5.3.6 Ammonia Type-C tanks:

(1) If carbon-manganese steels with higher yield properties other than those specified in 17.12.2 of CCS *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* are used, the completed liquid cargo holds and pipelines shall be subject to PWHT for stress relief.

(2) All butt welds in pipes made of carbon steel or carbon-manganese steel shall be subject to PWHT and shall meet the requirements of CCS *Rules for Materials and Welding*. The CCS may waive the thermal

stress relief requirement for pipes with a wall thickness of less than 10 mm, depending on the design temperature and pressure of the pipeline system concerned.

5.4 Welding procedure qualification

5.4.1 The welding procedure for butt welds and pipeline systems of Type-C tanks shall be approved by CCS and shall meet the requirements in Chapter 6 of CCS *Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*.

5.4.2 The welding test sample shall be representative of:

(1) Each type of base material;

(2) Each type of welding consumables and welding methods;

(3) Each welding position.

5.4.3 The following tests are required for welding procedure qualification of Type-C tanks:

(1) Transverse tensile test of weld;

(2) Longitudinal full-weld tensile test, which can be exempted for steel plates with a thickness of less than 16mm;

(3) Transverse bending test of weld: Forward, reverse or side bending tests can be carried out. Where the base material and weld metals are of different strength grades, longitudinal bending tests may be required in lieu of transverse bending tests;

(4) A set of 3 Charpy V-notch impact tests, with notches located at:

① Weld centerline;

② Fusion line;

③ In the heat affected zone (HAZ), and 1mm from the fusion line; and

④ In the HAZ, and 3mm from the fusion line; and

⑤ In the HAZ, and 5mm from the fusion line;

(5) It is also required to inspect the macro-section, micro-section and hardness of welds;

(6) For welding procedure tests of ammonia Type-C tanks, it is also required to carry out a hardness test on the weld cross-section (at 1.5mm from the surface) in accordance with Subsection 1.2.4.3, Section 2, Chapter 1, Part 3 of CCS *Rules for Materials and Welding*.

5.4.4 The welding procedure test shall meet the requirements below:

(1) Transverse tensile test of weld: The transverse tensile strength of weld shall not be lower than the minimum tensile strength of corresponding base material. If the tensile strength of weld metal is lower than that of base material, it can also be accepted after an agreement is concluded with CCS that the tensile strength of transverse weld shall not be lower than the specified minimum tensile strength of deposited metal. In each case, a report of the position at which the test sample breaks shall be provided for information.

(2) Longitudinal tensile test of weld: The yield strength of deposited metal shall not be lower than the specified minimum yield strength of base material or the minimum yield strength considered in design.

(3) Bending test: The sample shall not break after being bent 180° over a bending mandrel with a diameter four times the thickness of the sample, and the tensile surface of the bending test sample shall be free from open defects above 3mm.

(4) Impact test: This test shall be carried out at the temperature specified for the connecting base material. The minimum average impact energy (KV) of the weld metal impact test results shall not be less than 27J. The requirements for small-sized test sample of weld metal and individual impact energy shall be in accordance with Table 5.4.4(4). For impact tests of fusion line and HAZ, the minimum average impact

energy (KV) shall meet the transverse or longitudinal requirements (as applicable) of the base material. For small-sized test samples, the minimum average impact energy (KV) shall be as specified in Table 5.4.4(4). Where the material thickness does not permit taking full-size or standard small-sized test samples, the test method and acceptance criteria shall comply with recognized standards.

Table 5.4.4 (4) Minimum Average Value of Small-sized Test Sample

Size of Charpy V-notch Sample (mm)	Minimum Average Impact Energy of Three Samples (J)
10×10	KV
10×7.5	5/6KV
10×5	2/3KV

(5) Full penetration "Y" joint: according to the process test of fillet weld.

(6) The hardness test results for the welding procedure of ammonia Type-C tanks shall comply with CCS rules or standards recognized by CCS.

(7) For the butt welding test of plates, the test plate shall be so prepared that the weld is parallel to the rolling direction of plates. The range of material thickness specified for each welding procedure test and the scope of application shall meet the requirements in Chapter 3, Part 3 of CCS *Rules for Materials and Welding*. The test sample shall undergo 100% visual testing and100% surface and internal NDTs before cutting. NDTs shall be carried out after PWHT if required. For high-strength steels with a specified minimum yield strength of not less than 420N/mm2 used in welded structures, the NDT shall be delayed for at least 48h unless PWHT has been completed. The prior approval for NDT process shall be obtained from CCS. The visual testing and NDT results of test samples shall meet the requirements for Grade B in ISO 5817 or other equivalent standards (Grade C is acceptable for weld reinforcement, excessive convexity and root undercut).

5.4.5 All welds of ammonia Type-C tank shall be subject to welding procedure qualification, including butt welding, repair welding, tube-to-tube sheet welding, surfacing and fillet welding. On the premise of meeting the strength requirements, low-strength welding consumables shall be used as far as possible.

6 Materials and Components

6.1 Certification requirements

Main raw materials, parts and components used in manufacturing of Type-C tanks, such as plates, pipes and accessories, valves, expansion joints for fuel pipeline systems, heads and forged steel parts, shall have marine product certificates from CCS. Welding consumables, thermal insulation materials, laminated wood and adhesives shall have certificates of approval from CCS.

6.2 Re-inspection requirements

If the main raw materials mentioned above fail to meet certification requirements, the surveyor shall conduct a survey in accordance with the specifications. The survey items include chemical composition, mechanical properties, and NDT according to the product requirements. See Section 7.3 of the Guidelines for acceptance requirements. Welding consumables shall be subject to approval tests in accordance with Chapter 2, Part 3 of CCS *Rules for Materials and Welding*.

7 Type Test

7.1 Selection of typical samples

7.1.1 The characteristics and manufacturing methods of typical samples selected for approval type test shall cover or represent the product to be approved. Typical samples shall be selected with consideration given to: main body material, wall thickness, design pressure, design temperature, applicable medium, structural type (double-cylinder tank/three-cylinder tank) and other conditions. Generally, the structural types cannot cover each other, and the wall thickness shall generally be of the maximum specification.

7.2 Inspection of main raw materials, parts and components

7.2.1 Requirements for construction materials of Type-C tanks

(1) 7.2.1(1): Plates, pipes (seamless and welded pipes), sections and forgings used in Type-C tanks with a design temperature not below 0°C.

(2) 7.2.1(2): Plates, sections and forgings used in Type-C tanks with a design temperature ranging from below 0°C to -55°C.

(3) 7.2.1(3): Plates, sections and forgings used in Type-C tanks with a design temperature ranging from below -55°C to -165°C.

(4) 7.2.1(4): Pipes (seamless and welded pipes), forgings and castings used in pipeline systems with a design temperature ranging from below 0°C to -165°C.

Table 7.2.1(1) Plates, Pipes (Seamless and Welded Pipes) [Notes 1 and 2], Sections and Forgings Used in Type-C Tanks with a Design Temperature not Below 0°C

Chemical Composition and Heat Treatment	
Carbon-manganese steel	
Fully killed fine grain steel	
A small amount of alloying elements can be added with the consent of CCS.	
The range of chemical composition requires prior approval from CCS.	
Normalizing or quenching + tempering [Note 4]	
Strength and Toughness (Impact) Test Requirements	
Sampling frequency	
Plates	Test according to "rolled parts"
Sections and forgings	Test by batch
Mechanical properties	
Tensile properties	Specified minimum yield strength not above 410N/mm2 [Note 5]
Toughness (Charpy V-notch Impact Test)	
Plates	Transverse sample: minimum average impact energy (KV) 27J
Profiles and forgings	Longitudinal test sample: minimum average impact energy (KV) 41J
Test temperature	
Thickness t (mm)	Test temperature (°C)
t≤20	0
20＜t≤40	-20
40＜t≤50[See Note 3]	-20[See Note 6]

Note:

1. Seamless pipes and accessories can be manufactured using normal manufacturing processes. Welded pressure pipes shall meet the requirements in Chapter 4, Part 1 of CCS *Rules for Materials and Welding*.
2. Charpy V-notch impact test is not required for pipes.
3. This Table is generally applicable to materials not thicker than 50 mm. To use any material of a greater thickness, approval from CCS is required. In addition to the rolled steel requirements in Sections 2 and 3, Chapter 3, Part 1 of CCS *Rules for Materials and Welding*, an additional set of impact tests at the center of thickness is required for products with a thickness exceeding 40mm.
4. Controlled rolling process or thermo-mechanical control process (TMCP) may be used instead.
5. Materials with a specified minimum yield strength exceeding 410 N/mm2 require approval from CCS. Special attention shall be paid to the hardness of welds and HAZs of these materials. For potential stress corrosion cracking in a Type-C tank caused by goods carried, it

is advisable to perform a heat treatment across the tank to eliminate residual stress so that the hardness of weld metal and HAZ does not exceed 250HV.

6. In this case, PWHT for stress relief shall also be carried out. If an alternative method (e.g., engineering critical assessment) is used instead of PWHT for stress relief, it requires prior approval from CCS or shall comply with standards recognized by CCS.

Table 7.2.1 (2) Plates, Sections and Forgings Used in Type-C Tanks with a Design Temperature Ranging from Below 0°C to -55 °C [Note 1]

Maximum Thickness 25mm [Note 2]

Chemical Composition and Heat Treatment					
Carbon-manganese steel					
Fully killed, aluminum-treated fine grain steel					
Chemical Composition (Furnace Pot Analysis)					
C	Mn	Si	S	P	
≤ 0.16% [Note 3]	0.7~1.60%	0.1~0.50%	≤0.025%	≤0.025%	
Selection of added elements: alloying elements and grain refinement elements shall generally meet the following requirements:					
Ni	Cr	Mo	Cu	Nb	V
≤0.8%	≤0.25%	≤0.08%	≤0.35%	≤0.05%	≤0.1%
Total Al content min. 0.02% (acid solubility min. 0.015%)					
Normalizing or quenching + tempering See [Note 4]					
Strength and Toughness (Impact) Test Requirements					
Sampling frequency					
Plates	Test according to "rolled parts"				
Profiles and forgings	Test by batch				
Mechanical properties					
Tensile properties	Specified minimum yield strength not above 410N/mm2 [Note 5]				
Toughness (Charpy V-notch Impact Test)					
Plates	Transverse sample: minimum average impact energy (KV) 27J				
Profiles and forgings	Longitudinal test sample: minimum average impact energy (KV) 41J				
Test temperature	5°C below the design temperature or -20°C, whichever is lower				
Thickness t (mm)	Test temperature (°C)				

Note:

1. Requirements for Charpy V-notch impact test and chemical composition of forgings may be specially considered by CCS.
2. For materials over 25 mm thick, Charpy V-notch impact tests shall be carried out in accordance with the following requirements:

Material Thickness (mm)	Test Temperature (°C)
25＜t≤30	10°C below design temperature or -20°C, whichever is lower
30＜t≤35	15°C below design temperature or -20°C, whichever is lower

35＜t≤40	20°C below design temperature
40＜t	CCS-approved temperature Note 6

The impact energy value shall be that listed in the table according to the type of sample used. Materials used for liquid cargo holds and their components may be tested at a temperature 5°C below the design temperature or -20°C, whichever is lower, provided that thermal stress is completely eliminated after welding.

The test temperature for thermally stress-relieved stiffening members and other members shall be the same as that required for the thickness of the adjoining liquid cargo hold shell.

3. With special consent of CCS, the carbon content of the material may be increased to a maximum of 0.18% if the design temperature is not lower than -40°C.
4. Controlled rolling process or TMCP may be used instead.
5. Materials with a specified minimum yield strength exceeding 410 N/mm2 require approval from CCS. Special attention shall be paid to the hardness of welds and HAZs of these materials. For potential stress corrosion cracking in a Type-C tank caused by goods carried, it is advisable to perform a heat treatment across the tank to eliminate residual stress so that the hardness of weld metal and HAZ does not exceed 250HV. For materials over 25 mm thick, steels specified in 7.2.1(3) of the Guidelines or specially treated steels should be used if the test temperature is -60°C or lower.
6. For liquid cargo holds with a design temperature of not lower than -55°C and not higher than 0°C, the Charpy V-notch impact test for materials with a thickness of greater than 40mm and not greater than 50mm shall be carried out in accordance with the requirements below:

Charpy V-notch Impact Test Requirements	
Thickness (mm)	Test Temperature (°C)
40<t≤50 Note 7	5°C below the design temperature or -20°C, whichever is lower Note 8

7. In addition to the rolled steel requirements in Sections 2 and 3, Chapter 3, Part 1 of CCS *Rules for Materials and Welding*, an additional set of impact tests at the center of thickness is required for products with a thickness (t) exceeding 40mm.
8. When the design temperature is below 0°C to -10°C, PWHT shall be carried out for stress relief. When the design temperature is below -10°C to -55°C, PWHT shall be carried out for Type-C tanks made of carbon-manganese steel. If an alternative method (e.g., engineering critical assessment) is used instead of PWHT for stress relief, it requires prior approval from CCS or shall comply with standards recognized by CCS.

Table 7.2.1 (3) Plates, Sections and Forgings Note 1 Used in Type-C Tanks with a Design Temperature Ranging from Below -55°C to -165°C Note 2

Maximum Thickness 25mm Notes 3 and 4

Minimum Design Temperature (°C)	Chemical Composition Note 5 and Heat Treatment	Impact Test Temperature (°C)
-60	1.5% nickel steels - normalizing or normalizing + tempering or quenching + tempering or TMCP Note 6	-65

-65	2.25% nickel steels - normalizing or normalizing + tempering or quenching + tempering or TMCP Notes 6 and 7	-70
-90	3.5% nickel steels - normalizing or normalizing + tempering or quenching + tempering or TMCP Notes 6 and 7	-95
-105	5% nickel steels - normalizing or normalizing + tempering or quenching + tempering Notes 6, 7 and 8	-110
-165	9% nickel steel - secondary normalizing + tempering or quenching + tempering Note 6	-196
-165	Austenitic steels, such as 304, 304L, 316, 316L, 321 and 347, solution treatment Note 9	-196
-165	High manganese austenitic steels - hot rolling and controlled cooling Notes 10 and 11	-196
-165	Aluminum alloys such as 5083, annealing	Not required
-165	Austenitic iron-nickel alloys (with 36% Ni), using the agreed heat treatment method	Not required

Tensile and Toughness (Impact) Test Requirements	
Sampling frequency	
Plates	Test according to "rolled parts"
Profiles and forgings	Test by batch
Toughness (Charpy V-notch Impact Test)	
Plates	Transverse sample: minimum average impact energy (KV) 27J
Profiles and forgings	Longitudinal test sample: minimum average impact energy (KV) 41J

Note:

1. Impact test requirements for forgings used in critical conditions shall be specially considered by CCS.
2. The requirements for design temperature lower than -165°C shall be specifically agreed with CCS.
3. Materials containing 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni over 25 mm thick shall be subject to impact tests as follows:

Material Thickness (mm)	Test temperature
25＜t≤30	10°C below design temperature
30＜t≤35	15°C below design temperature
35＜t≤40	20°C below design temperature

   The impact energy value shall be that listed in the table according to the type of sample used. Charpy V-notch impact energy values for material thicker than 40mm will be specially considered (see Note 12).
4. 9%Ni steels, austenitic stainless steels and aluminum alloys with a thickness of over 25 mm

may be used.

5. The range of chemical composition shall comply with recognized standards.
6. TMCP nickel steel shall be that accepted by CCS.
7. Quenched and tempered steels may be used for lower minimum design temperatures with special consideration by CCS.
8. 5% nickel steel with special heat treatment, such as 5% nickel steel that has undergone three heat treatments, can be used in applications with a minimum temperature of -165°C, but it should undergo impact tests at -196°C.
9. With the consent of CCS, the impact test can be exempted.
10. For ships built on or after January 1, 2026, materials shall be used in accordance with the relevant requirements of IMO Circular "Revised Guidelines on the Application of High Manganese Austenitic Steel for Cryogenic Service" (MSC.1/Circ.1599/Rev.2 and amendments) or CCS *Application Guidelines on High Manganese Austenitic Cryogenic Steel*.
11. For high manganese austenitic steels, the impact test shall not be exempted.
12. For materials with a thickness of greater than 40mm and not greater than 50mm, Charpy V-notch impact tests shall be carried out in accordance with the following requirements:

Toughness (Charpy V-notch Impact Test)	
Thickness t (mm)	Test temperature
40<t≤45 Note 13	25°C below design temperature
45<t≤50 Note 13	30°C below design temperature

13. In addition to the rolled steel requirements in Sections 2 and 3, Chapter 3, Part 1 of CCS *Rules for Materials and Welding*, an additional set of impact tests at the center of thickness is required for products with a thickness (t) exceeding 40mm.

Table 7.2.1(4) Pipes (Seamless and Welded Pipes) [Note 1], Forgings [Note 2] and Castings [Note 2] Used in Fuel Pipelines and Pipelines for Treatment with a Design Temperature Ranging from Below 0°C to -165°C[Note 3]

Maximum Thickness 25mm

Minimum Design Temperature (°C)	Chemical Composition Note 5 and Heat Treatment	Impact Test	
		Test temperature °C	Minimum Average Impact Energy KV
-55	Carbon-manganese steels: They shall be fully killed fine grain steels, normalized or heat treated by agreed methods Note 6.	Note 4	27
-65	2.25% nickel steel - normalizing or normalizing + tempering or quenching + tempering Note 6	-70	34
-90	3.5% nickel steel - normalizing or normalizing + tempering or quenching + tempering Note 6	-95	34
-165	9% nickel steel Note 7, secondary normalizing + tempering or quenching + tempering	-196	41
	Austenitic steels, such as 304, 304L, 316, 316L, 321 and 347, solution treatment Note 8	-196	41
	Aluminum alloys such as 5083, annealing		Not required
Tensile and Toughness (Impact) Test Requirements			
Sampling frequency			
Test by batch			
Toughness (Charpy V-notch Impact Test)			
Impact test: longitudinal test sample			

Note:

1. To use longitudinal welded and spiral welded pipes, prior special approval from CCS is required.
2. The requirements for forgings and castings may be specially considered by CCS.
3. The requirements for design temperature lower than -165°C shall be specifically agreed with CCS.
4. The test temperature shall be 5°C lower than the design temperature or -20°C, whichever is lower.
5. The range of chemical composition shall comply with recognized standards.
6. With special consent of CCS, a lower design temperature can be used for quenched and tempered materials.

7. Chemical composition is not applicable to castings. 8. With the consent of CCS, the impact test can be exempted.

7.2.2 Ammonia: Fine grain steels shall be used if carbon-manganese steel is used for fuel tanks, fuel pipelines and other tanks/cabinets containing fuel or ammonia. The nominal minimum yield strength shall not exceed 355 N/mm2, and the actual yield strength shall not exceed 440 N/mm2. For carbon-manganese steels with the steel grades of CL-II-2 and CL-III-2 and requiring PWHT for stress relief, one of the following structural or operational measures shall also be taken:

(1) Use lower strength material with a nominal minimum tensile strength not exceeding 410 N/mm2;

(2) Carry out PWHT of fuel tank for stress relief;

(3) Maintain the ammonia temperature preferably at its boiling point of -33°C, but not higher than -20°C;

(4) Ensure that water content in ammonia not less than 0.1%w/w.

If carbon-manganese steels with yield properties exceeding the specified limits above are used in ammonia Type-C tanks, PWHT is required for components such as fuel tanks and pipelines for stress relief. The tensile and yield properties of welding consumables used for ammonia Type-C tanks and ammonia fuel pipelines shall exceed the minimum practical values of tensile and yield properties of fuel tank or pipeline materials.

7.2.3 If PWHT of Type-C tanks is required for stress relief according to the design or relevant requirements, the performance of the base material after heat treatment shall be verified. The (tensile and impact) performance of the base material shall be determined in the heat treatment condition in accordance with the applicable tabulated requirements of this Clause. Generally, steel plates with a smaller thickness or positions under larger stress as indicated by calculations should be selected before construction, along with steel pipes with a smaller wall thickness, to prepare test samples of adequate size. After heat treatment together with the welded Type-C tank, these test samples shall be processed into samples for testing.

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. The method, time and temperature of preheating before welding and heat preservation after welding shall meet the approved welding procedure specifications or process documents.

7.3.2 Pre-welding inspection:

(1) Before welding, oxides, moisture, oil stains and other contaminants that may affect the welding quality shall be removed from the surface within an area of at least 25mm from the groove and welding edge. Tack welding and edge defects that affect the welding quality shall be removed before welding.

(2) Groove angle, dimension, chamfering length, butt gap and cleanliness shall meet the requirements of drawings approved by CCS, welding procedure specifications recognized by CCS, and CCS rules.

(3) The misalignment between two plate surfaces of butt welds of cylindrical pressure shell shall not exceed 10% of the plate thickness at any point, and that for longitudinal welds shall not exceed 3mm, and that for circumferential welds shall not exceed 4mm. The misalignment between two plate surfaces of butt welds at head joints of spherical pressure shell and cylindrical pressure shell shall not exceed 10% of the plate thickness at any point and shall not exceed 3mm.

(4) If the shell is made of plates (tube sheet and covering plate) with different thicknesses, they shall be assembled to form a continuous circle on one side. The specific requirements are as follows:

① For longitudinal welds, the edge of the thicker plate shall be chamfered inside and outside by machining. The width of the chamfer in the circumferential direction shall be at least four times the thickness difference between the plates to ensure that the edges of both plates have equal thickness at the weld. For circumferential welds, the edge of the thicker plate shall be also chamfered in a

similar manner with the width of the chamfer in the longitudinal direction as required above;

② For circumferential welds, the edge of the thicker plate shall be chamfered by machining if the thickness difference is the same throughout the circumference. The width of the chamfer shall be at least four times the thickness difference between the plates to ensure that the edges of both plates have equal thickness at the circumferential weld;

③ When the weld is wide enough to form a bevel transition as specified in (1) and (2) above on the weld surface, the requirement to chamfer the base material surface can be waived.

(5) The circumferential edge (E) formed at the weld joint shall be checked by using the inner or outer sample plate with a chord length equal to 1/6 of the inner diameter (with a total length not exceeding 1200mm) and not less than 300mm (see Figure 7.3.2(5)). The E value shall not be greater than (δs/10+2) mm and not greater than 5mm.

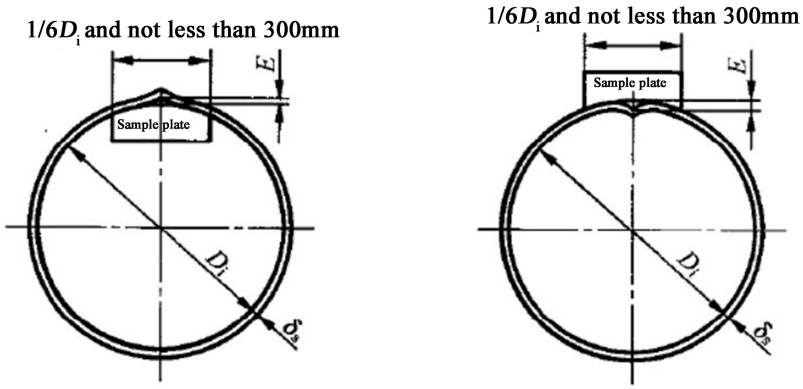

Figure 7.3.2(5) Circumferential Edge at Weld Joint

7.3.3 Welding: The welding operation should be conducted under sheltered conditions with protection against rain and snow, with additional measures taken to avoid wind interference. When the ambient temperature is low or the humidity is high, reliable preheating or dehumidification measures shall be available for use. The manufacturer shall carry out welding in accordance with the approved welding procedure specifications or process documents, and record the weld number and main

welding parameters;

7.3.4 Post-welding inspection: After welding, the appearance quality of welds shall be inspected. The weld surface 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. The outer surface of the weld can be flush with the surface of the shell plate, or it can be made so that the total thickness at the center of the weld is slightly greater than the plate thickness. However, any changes in the cross-section due to weld reinforcement should be smoothly transitioned. The weld reinforcement of butt welds and the leg of fillet welds shall comply with the drawings or standards recognized by CCS.

7.4 Product weld test

7.4.1 Product weld tests should generally be performed for approximately each 50m of butt weld joints and full penetration "Y" joints, and should be representative of various welding positions. The material grade and thickness of the product welding test plate shall be the same as those of the shell material. Each pair of test plates must consist of two plates. Each plate should have a minimum width of 150mm and a length sufficient to provide the complete set of samples specified in this section and the required retest samples. The groove of the test plate shall be the same as that of the cylinder weld. The test plate shall be tack welded to the cylinder shell plate, ensuring that the weld between the two test plates serves as a continuation and simulation of the longitudinal weld of the cylinder shell plate. For spherical tanks or circumferential welds, test samples for simulation of circumferential weld shall be produced through welding. These test samples shall be large enough to provide the complete set of samples specified in this section and the required retest samples.

7.4.2 All welds on the test plates must undergo 100% surface and radiographic testing prior to the product weld test. The test and acceptance criteria should meet or exceed the standards for the corresponding welds.

7.4.3 Butt weld test items:

(1) Transverse tensile test of weld: See the requirements in 5.4.4(1);

(2) Longitudinal tensile test of weld: See the requirements in 5.4.4(2);

(3) Bending test: See the requirements in 5.4.4(3);

(4) Impact test: The notches of Charpy V-notch impact test samples shall be alternately located in the center of weld or in the HAZ (the most dangerous position determined according to the results of welding procedure test). For austenitic stainless steels or austenitic steels, all notches shall be located in the center of the weld. The impact test shall be carried out at the temperature specified for the connecting base material. The minimum average impact energy (KV) of the weld metal impact test results shall not be less than 27J. The requirements for small-sized test sample of weld metal and individual impact energy shall be in accordance with Table 5.4.4(4). For impact tests of fusion line and HAZ, the minimum average impact energy (KV) shall meet the transverse or longitudinal requirements (as applicable) of the base material. For small-sized test samples, the minimum average impact energy (KV) shall be as specified in Table 5.4.4(4). Where the material thickness does not permit taking full-size or standard small-sized test samples, the test method and acceptance criteria shall comply with recognized standards.

(5) Full penetration "Y" joint: according to the process test of fillet weld;

(6) The hardness test results for the product weld test of ammonia Type-C tanks shall comply with CCS rules or standards recognized by CCS.

7.5 Visual and dimension inspection

7.5.1 Welded Type-C tanks shall undergo comprehensive internal and external visual testing to ensure the surface is free from any scars. The welding scars and other defects on the tank shall be removed or cut off at 3-5mm from the cylinder surface, and then polished.

7.5.2 The pressure shell shall be checked for local deviations such as cylinder out-of-roundness and overall dimensions before and after the completion of manufacturing and final heat treatment. Cylinder out-of-roundness refers to the difference between the maximum and minimum inner diameters measured on the same section. It is required to comply with Chapter 7, Part 3 of CCS R*ules for*

Materials and Welding, the approved drawings and standards recognized by CCS.

7.5.3 Unless otherwise specified in the drawings, the allowable deviation of shell straightness shall not exceed 5‰ of the shell length. The shell straightness inspection is conducted along the horizontal and vertical planes of the centerline by taking measurements at four positions around the circumference: 0°, 90°, 180° and 270°. The measuring position shall not be less than 100mm from the weld centerline of Category A joints (excluding spherical head-to-cylinder joints and set-in nozzle-to-shell butt joints). If the shell thickness varies, the thickness difference shall be subtracted for straightness calculation.

7.6 NDT of welds

7.6.1 The NDT shall be carried out after the weld has cooled to ambient temperature. If applicable, it shall be carried out after PWHT. Weld test process and acceptance criteria shall be submitted to CCS for approval. If higher standards or tolerances are assumed in the design, they must also be achievable. In principle, radiographic testing shall be used to detect internal defects. Approved ultrasonic testing may be used as an alternative to radiographic testing. However, some locations should still undergo radiographic testing to verify the results. The results of radiographic and ultrasonic testing shall be kept.

7.6.2 For independent Type-C liquid cargo holds, the extent of NDT may be determined as all or part of the positions as per recognized standards. However, the extent of survey shall not be less than that specified below:

(1) The welding effective coefficient used in the calculation is 0.95. If other factors are considered, such as the material used, joint type, welding method and load type, this coefficient can be increased to 1 for the NDT of all welds:

① Radiographic testing: all butt welds within the whole length;

② NDT for surface crack inspection:

(a) All welds within 10% of the length;

(b) Reinforcing rings around openings and nozzles along the

entire length.

③ In principle, radiographic testing shall be used to detect internal defects. However, approved ultrasonic testing may be used as an alternative to radiographic testing. In addition, the competent authority may also require a comprehensive ultrasonic testing of the reinforcing ring and the nozzle weld around the opening.

(2) The welding effective coefficient used in the calculation is 0.95. If other factors are considered, such as the material used, joint type, welding method and load type, this coefficient can be increased to 1 for the NDT of some welds:

① Radiographic testing: At least 10% of the entire length of all joints and butt welds at butt welding intersections shall be uniformly selected for testing;

② NDT for surface crack inspection:

(a) Reinforcing rings around openings and nozzles along the entire length;

③ Ultrasonic testing:

(b) Requests may be made by the competent authority on a case-by-case basis.

(3) See the following table for specific testing methods and scope:

Table 7.6.2 (3) NDT Positions and Requirements for Type-C Tank and Pipeline System

S/N	Position of Weld	Testing Method			
		RT	UT	PT/MT	VT
1	Full penetration butt weld of shell (including heads)	100%		10%	100%
2	Longitudinal full penetration butt weld of dome, liquid collecting well and manhole	100%		10%	100%
3	Butt weld of pump pipeline	100%		10%	100%
4	Butt weld of pipeline system outside the tank	100%		10%	100%
5	Full penetration "Y" welds of longitudinal bulkhead and shell		100%	100%	100%

6	Butt weld of longitudinal bulkhead plate		10%	10%	100%
7	"T" welds of dome, liquid collecting well and cylinder; "T" welds of manhole, pump pipeline and air chamber		100%	100%	100%
8	"T" weld between deck tank nozzle and shell		100%	100%	100%
9	"T" weld between air chamber nozzle and head		100%	100%	100%
10	Butt weld of reinforcing ring panel and web		10%	10%	100%
11	"T" welds between pump flange and pump pipeline, manhole flange and shell ring		100%	100%	100%
12	Fillet welds between lifting lug and reinforcing plate and shell			100%	100%
13	Welds caused by repair welding, weld joints of temporary fixture feet, or welds resulting from other misoperations			100%	100%
14	Fillet weld of reinforcing plate at opening or nozzle			100%	100%
15	Fillet welds other than above			10%	100%
16	After back gouging of all full penetration welds			100%	100%
17	All shell plate full penetration butt welds after hydraulic test		10%		100%

Note:

(1) RT - Radiographic Testing; UT - Ultrasonic Testing; MT - Magnetic Particle Testing; PT-Dye Penetrant Testing; VT - Visual Testing

(2) NDT standards and weld quality evaluation standards:

① Applicable standards and testing technology class

(a) RT: EN 1435 Class B, NB/T47013.2 Class AB;

(b) UT: ISO 17640 Class B, NB/T47013.3 Class B;

(c) PT/MT: ISO17638, ISO9934, NB/T47013.4-5.

② Evaluation standards

(a) RT: ISO5817-B, NB/T47013.2 Class II. In addition, defects such as crack, incomplete fusion and incomplete penetration are not allowed;

(b) UT: Class A and B welds: full test is required: ISO5817-Class B, NB/T47013.3 Class I; local test is required: NB/T47013.3 Class II. In addition, defects such as crack, incomplete fusion and incomplete penetration are not allowed;

(c) PT/MT: Chapters 6 and 7 of ASME-V, Class I in NB/T47013.4-5.

(3) The testing technology class and acceptance level equivalent to or not lower than the above standards can be selected for testing.

7.6.3 For the NDT of welds, the influencing factors of delayed cracking shall be taken into account. For high-strength steels with a specified minimum yield strength ranging from 420 N /mm2 to 690 N /mm2 used in welded structures, the NDT shall not be carried out within 48 hours after completion of welding. For steels

with a specified minimum yield strength greater than 690 N/mm2, the NDT shall not be carried out within 72 hours after completion of welding. The NDT should be delayed if there is any evidence of delayed cracking in welds, regardless of the yield strength.

7.6.4 If other advanced NDT methods such as Phased Array Ultrasonic Testing (PAUT) and Time of Flight Diffraction (TOFD) are used instead of radiographic testing, the testing process documents shall be submitted according to Appendix 2 of Part 3 of CCS *Rules for Materials and Welding* before testing. Additionally, process verification test and on-site examination shall be carried out after being approved by CCS.

7.6.5 Weld defect rectification

(1) The weld defect rectification process shall be submitted to CCS for approval and shall include defect removal method, necessary NDT after defect removal and method and scope of NDT after rewelding. It can be used only after being approved by CCS. The results of re-inspection after repair welding shall be to the satisfaction of the CCS surveyor.

(2) 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. Defect rectification and repair welding shall be completed prior to PWHT. Generally, the same position of pressure shell allows weld defect rectifications twice at most.

(3) If any unallowable defect is identified in a weld during spot check, two additional positions along the length of the weld represented by the checked weld shall be selected for further inspection. If acceptable in re-inspection, the defects in the original weld shall be removed before repair welding. If still unacceptable in re-inspection, one of the following measures shall be taken:

① The whole length of the weld represented by the checked weld shall be

removed, and re-welding is required. The weld shall undergo a spot check as a new weld, and the corresponding test sample shall undergo the same process.

② The entire length of the weld represented shall be checked. All defective parts shall be repaired, and then all repaired parts shall be re-checked.

7.7 Internal structure and assembly inspection

The inspection shall cover the completed internal structure, installation position, as well as the dimensions, installation positions and heights of pipelines in the tank. All inspection results shall meet the requirements of the approved drawings.

7.8 Hydrostatic and tightness tests

7.8.1 Hydrostatic tests must be conducted on all Type-C tanks following their manufacturing. During these tests, the pressure measured at the tank top shall not be less than 1.5 times the design pressure (P). However, in any case during tests, the calculated main diaphragm stress at any point shall not exceed 90% of the yield stress of the material at the test temperature. 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 type test, except for simple cylindrical or spherical pressure vessels. The water temperature used in the test should be at least 30°C higher than the ductile-to-brittle transition temperature of the manufacturing material. In the hydrostatic test, the pressure should be maintained for 2h per 25mm of plate thickness, but in no case less than 2h. If required, a hydro-pneumatic pressure test can be performed.

7.8.2 After assembly and completion, each Type-C tank shall undergo the tightness test which may be carried out in conjunction with the pressure test as mentioned in 7.8.1. The test pressure shall comply with product standards and design drawings. Other tightness test methods if used shall conform to the standards accepted by CCS.

7.9 Thermal insulation construction inspection (if application)

7.9.1 This inspection is not regarded as an approved type test item. Whether it

is taken as a product factory inspection item shall be determined by all parties through negotiation.

7.9.2 Thermal insulation construction is usually carried out at the Type-C tank manufacturer according to the thermal insulation construction manual provided by the thermal insulation material manufacturer.

7.9.3 The inspection items can be negotiated by all parties, including: inspection of thermal insulation materials after entering the factory, inspection of temperature and humidity of construction site and tank surface before spraying, adhesion inspection of polyurethane test plate or tank body, sampling inspection of polyurethane used for tank body, welding test of fixing bolt (if any) and completion inspection.

7.9.4 The thickness and structural type of thermal insulation layer shall be checked. The thickness of main thermal insulation materials at the tank body, air chamber, saddle support, anti-floating device, etc. shall not be lower than that required in the thermal insulation calculations or approved drawings. The structural type shall be consistent with the approved design.

8 Unit/Batch Inspection

8.1 For the unit/batch inspection, the manufacturer shall submit the inspection and test program, inspection and test plan (ITP), welding procedure specifications, NDT specifications and hydrostatic/tightness test specifications. Relevant operations can be made after approval is obtained from CCS.

8.2 Type-C tanks shall be manufactured by factories approved by CCS. The approved unit/batch inspection items of Type-C tank shall specifically include:

(1) Inspection or re-inspection of main raw materials;

(2) Welding inspection: pre-welding inspection, welding inspection and post-welding inspection of welds;

(3) Product weld test;

(4) Visual and dimension inspection;

(5) NDT of welds;

(6) Hydrostatic and tightness tests;

(7) Internal structure and assembly inspection;

(8) Thermal insulation construction inspection (if application).