Guideline No.W-17(202407)

W-17

CLAD STEEL PLATE

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Foreword

CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed mp@ccs.org.cn.

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Main changes:

1. Supplement and improvement: cladding methods for clad steel plates, types of cladding material, definitions of relevant terms, production equipment requirements for rolled processes, repair process requirements, raw material requirements, requirements for tensile test elongation, and requirements for corrosion testing.

2. Other editorial modifications.

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CLAD STEEL PLATE

1 Application

1.1 This Guideline applies to the works approval and product inspection of clad steel plates produced in accordance with the requirements of CCS *Rules for Materials and Welding* and taking carbon steel and carbon manganese steel as the base material. If the plates are to be used as a part of the hull structure (such as liquid cargo tank) or for pressure vessels, the base material is to comply with the relevant provisions of the *Rules*.

1.2 This Guideline applies to clad steel plates produced by the explosion cladding method, rolled cladding method, explosion rolled cladding method and so on.

1.3 Any material suitable for the intended purposes, such as stainless steel, aluminum alloy, titanium alloy, nickel alloy or copper etc., may be accepted as cladding material.

2 Normative references

2.1 *CCS Rules for Materials and Welding*

2.2 Relevant national/international standards, etc.

3 Terms and definitions

3.1 Clad steel plates

Clad steel plate is the plate consisting of a base plate clad on one or both sides, continuously and integrally bonded with a thin layer of cladding material.

3.2 Base material

The material that mainly bears structural strength in clad steel plates.

3.3 Cladding material

The material mainly in contact with the working medium in clad steel plates.

3.4 Explosion cladding method

The cladding method for achieving metallurgical welding between the base material and the cladding material during the explosion process.

3.5 Rolled cladding method

The method for achieving cladding through rolled process.

3.6 Explosion rolled cladding method

First, the initial cladding of the base material billet and the cladding material billet is carried out by explosion method, and then the rolled cladding method is carried out.

4 Drawings and documents

4.1 The organizations going for works approval from CCS are to submit the application to CCS for works approval.

4.2 The following are to be submitted to CCS for review.

4.2.1 Factory profile:

Name, address and production history; types and specifications of existing products; types, specifications and delivery conditions of products to be approved; specifications, delivery conditions, chemical compositions and mechanical properties of metal plates (steel grades or designations of base metal and clad metal) forming the products to be approved; and other qualification certificates granted to the factory.

4.2.2 Management documents like quality system management (QMS) document:

(1) Organizational structure, quality control points, responsibilities of management departments/ managers, quality management system document, identification and traceability management regulations or relevant descriptions;

(2) For the raw materials processing factory needing to purchase steel plates or other metal plates, procurement and acceptance regulations for raw materials are to be established and the purchasing list of raw materials is to be submitted to CCS. The list is to be issued in the form of official document of the factory, including: names of raw materials, name of the manufacturer, number of CCS Certificate of Works Approval awarded to the manufacturer, number of factory document, official seal of the factory, etc.

3.2.3 Main production equipment and main inspection/test equipment:

(1) List of main production equipment including (based on different production processes): welding machine, cutting machine, flattening machine, grinding machine, heat treatment furnace (annealing furnace), rolling mill, heating furnace, vacuum assemble billet equipment etc.;

(2) List of main inspection/test equipment including: chemical composition analysis equipment, mechanical properties test equipment, nondestructive test equipment, corrosion test equipment, etc. The inspection/test equipment is to be provided by the manufacturer.

4.2.4 Process documents:

Production process flow chart, control standard for the product type to be approved and process operation instructions (SOP), mainly including:

(1) Production process flow chart

(2) Raw material preparation process documents: purchasing standards for base material and cladding material, including chemical compositions, mechanical properties, dimensions and surface inspection requirements, non-destructive detection standards and surface quality standards.

(3) Raw material acceptance standard: the raw material is to be inspected and re-tested for relevant items according to corresponding standards or technological requirements. The designation, heat number, dimensions, thickness, surface quality and flatness of incoming material are to be checked against the ordering specifications. Non-destructive detection is to be conducted on the base material to make sure whether the defect of the clad steel plate arising in subsequent production is caused by the raw material or by the cladding process.

(4) Cutting process documents for base and clad material

(5) Surface treatment process document before cladding

(6) Cladding process document

① Explosion cladding method

Explosion cladding process.

② Other methods such as the rolled method

(a) Assembly process

(b) Rolled process

(7) UT: standard and acceptable criterion and index are to be used.

(8) Heat treatment process document

① Heat treatment method (such as stress relief annealing);

② Heating-up temperature and time;

③ Furnace cooling temperature and air cooling time;

④ Heat treatment is one of the important methods to ensure the product properties. In spite of the key role of heat treatment, the proper heat treatment equipment may be selected depending on the factory situation.

(9) Flattening process document

(10) Surface treatment process document

(11) Document of machining and sampling methods for finished products

(12) Document of inspection method and process for finished products

(13) Marking, packaging and storage document

(14) Repair process

4.2.5 Competency certificates of testers and inspectors;

4.3 The type test program is to be submitted to CCS for approval.

4.4 Other documents required by CCS.

5 Technical requirements

5.1 The plates are to be supplied in a heat treated condition most appropriate to both the base and cladding materials. The heat treatment procedure is to be submitted to CCS for reference.

5.2 Defects in the cladding material of cladding steel plates can be repaired, and the repair should be carried out according to the approved repair process by CCS.

6 Materials and components

The base and cladding material should comply with the corresponding provisions of CCS *Rules for Materials and Welding* according to the intended use of the product. If it is an externally purchased sheet metal, it should hold CCS marine product certificate or equivalent documents.

7 Type test

7.1 Determination of type test program

Before the type test for works approval, CCS and the applicant are to determine the type test program for the product to be approved through negotiation. The type test program may be proposed by the applicant and is to be acknowledged and approved by CCS; it may also be

proposed by CCS and is to be acknowledged by the applicant. The type test program is to include the following content:

(1) The type, specifications and delivery condition of the product to be approved (the specifications, designations and delivery conditions of corresponding base material and clad material are to be specified);

(2) Information about the type, specifications, quantity and delivery condition of the typical product selected for type test;

(3) Type test items and applicable rules and standards;

(4) Sampling position, schematic diagram and sampling instructions;

(5) Test location and laboratory qualifications (in the case of subcontract, the subcontractor qualifications and subcontract agreement content are to be provided);

(6) Name of test agency.

7.2 Selection of typical product for type test

Principles for the selection of typical product for type test:

(1) For the product to be approved, samples are to be taken from the products covering the maximum and minimum processing capabilities for type test. (For example, both the maximum and the minimum specifications are to be selected for the thickness of base material plate and the thickness of cladding material plate.)

(2) For clad steel plates formed by different cladding methods, different heat treatment methods or different production methods, alternative sampling methods may not be appropriate.

(3) The steel plate for the test is to be specified by the Surveyor, and the type test specimens are to be taken at the head and tail of steel plate.

7.3 Type test Items and requirements

See Table 7.3 for the type test items and requirements. The details are as follows:

7.3.1 Chemical composition analysis

The chemical compositions of base material and cladding material are to be inspected respectively in accordance with the constructions of base material plate and cladding material plate.

7.3.2 Tensile test

(1) Generally, full-thickness plates are to be taken as tensile test specimens. Where the thickness of the plate is more than 50 mm, or in order to suit the capacity of the testing

machine, the thickness of the test specimen may be reduced by machining according to CCS rules.

(2) The tensile test specimens are to be taken longitudinally and transversely, and the determination of the test result is to be based on the CCS Rules. The elongation after fracture should not be less than the standard value of the base material. ①

Note: ①When the standard elongation of the cladding metal is less than the standard elongation of the base material, it is allowed for the elongation of the clad steel plate to be less than the standard elongation of the base material, but it should not be less than the standard elongation of the cladding metal. At this point, one tensile test of the base material sample should be added, and its elongation after fracture should not be less than the standard value of the base material.

7.3.3 Bending test

The bending test is to be conducted on both the front and the back respectively in accordance with the CCS Rules or national standards.

7.3.4 V-notch impact test

(1) The impact test specimen is to be taken at the point close to close to the base material surface; if necessary, the test specimen may be taken from the base material close to the faying face;

(2) The impact work of V-notch impact test is to be measured and the picture showing the fracture of the impact test specimen is to be provided.

(3) The requirements on the temperature of the impact test are as shown in Table 7.3.

(4) If the base material uses the base material of pressure vessel or other materials within the scope of CCS Rules, the test is to be conducted in accordance with the corresponding rules.

7.3.5 Shear test

The bonding quality of cladding metal and base material is to be firstly inspected through UT, and then the cutting property of each layer is to be measured respectively. The shear test is to be in accordance with the method approved by CCS. The shear strength of bonding face is to be not less than the following values:

(1) In the case of the tensile strength $Rm < 280$ N/mm^2, the shear strength is to be more than 50% of the tensile strength;

(2) In the case of the tensile strength $Rm \geq 280$ N/mm^2, the shear strength is to be more than 140 N/mm^2。

7.3.6 Metallographic microstructure

The metallographic picture of the bonding part between layers is to be provided according to the construction of the clad steel plate so as to show the bonding condition between layers of metal. Metallographic structure inspections of 100X and 500X are to be conducted respectively.

7.3.7 Nondestructive test

The bonding quality of clad metal and base material is to be inspected piece by piece through UT. All the areas at least 50 mm away from the surrounding edges are to undergo 100% inspection. The middle area is to undergo continuous inspection along the rectangle loop lines at an interval of 200 mm. The permitted single unbonded area is not to exceed 4000 mm^2, and the distance between single unbonded areas is not to more than 500 mm.

7.3.8 corrosion test

According to the intended use of the product, corresponding corrosion tests should be conducted on the cladding metal. Examples include intergranular corrosion tests on austenitic stainless steel and austenitic ferrite duplex stainless steel, pitting corrosion tests on austenitic ferrite duplex stainless steel, and intergranular corrosion tests on nickel alloys. The intergranular corrosion and pitting corrosion tests of stainless steel should comply with the requirements of CCS *Rules for Materials and Welding*, while the corrosion tests of other cladding metals should meet the requirements of the standards accepted by CCS. The corrosion test should be conducted on the cladding material after removing the base material.

7.3.9 Dimensions measurement and visual inspection

(1) Dimensions measurement and visual inspection are to be conducted at least one piece. The length, width, thickness and diagonal length of each clad steel plate are to be measured. The thickness measurement and thickness deviation should comply with the provisions of CCS *Rules for Materials and Welding* and relevant standards.

(2) The appearance quality is to meet the requirements of the relevant standards.

7.3.10 The sampling and mark transfer of type test is to be witnessed by the Surveyor.

8 Unit/batch inspection

8.1 According to the provisions of CCS *Rules for Classification of Sea-Going Steel Ships*, the unit/batch inspection of clad steel plates is to be conducted after works approval.

8.2 The factory is to be informed of the detailed requirements on the unit/batch inspection of clad steel plates in written form when CCS issues the Certificate of Works Approval.

8.3 The unit/batch inspection of clad steel plates is to be conducted in accordance with the approved inspection plan. The inspection plan is to include the inspection and test items to be witnessed and reviewed. The inspection items are to include mechanical properties test (tensile test, impact test, shear test, bending test), nondestructive test, chemical composition analysis, appearance and dimensions inspection, etc. If necessary, the Surveyor may check the process records and inspection records and propose additional test items.

8.4 After completing the product inspection, the CCS Surveyor is to sign and issue a certificate to the qualified product or attach the inspection seal on and sign the certificate of quality.

(1) The certificate of quality is to at least include the acceptance bases (rules, standards and technical agreements), heat/batch number, the type and designation of each layer, size, weight, quantity, delivery condition, chemical compositions, mechanical properties, and product marking description with the reserved space for signature and sealing by the CCS Surveyor.

(2) The format of the certificate of quality is to be approved by CCS.

Type approval test items **Table7.3**

Test item	Applicable steel grade and designation	Sampling requirement	Test requirement	Remark
Chemical composition	Each layer of metal plate	Finished product	In accordance with the requirements on each layer of metal	
Tensile test	—	1/4 of the width of the head and tail ends, longitudinally and transversely	R_{eH}, R_m, A_5	
Bending test	—	1/4 of the width of the head and tail ends, longitudinally and transversely	-	
Shear test	The bonding part between layers	1/4 of the width of the head and tail ends, longitudinally and transversely	Shear strength	
Impact test (corresponding to the base material)	—	1/4 of the width of the head and tail ends, longitudinally and transversely	Test temperature ℃	
	A,		Grade A: room temperature Grade B/AH32/AH36: 0 D,DH32,DH36: -20 E/EH32/EH36: -40 FH32/FH36: -60	
	B, A32/36/40,			
	D, DH32/36/40,			
	E, EH32/36/40,			
	FH32/36/40,			
	Other materials specified in the CCS Rules		In accordance with the CCS Rules	
Microstructure	Each layer of metal plate and the bonding part between layers	One end		
Non-destructive detection	Each layer of metal plate before cladding and the entire clad steel plate after cladding	Each layer of metal plate and the entire clad steel plate		
Corrosion test	Stainless steel and nickel alloy etc.	Two ends		When corrosion performance is required
Dimension and appearance inspection	—	The entire plate	Related standard	