GUIDANCE NOTES
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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR SURVEY OF LEAN DUPLEX STAINLESS STEEL

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CHAPTER 1 GENERAL

1.1 Objective

1.1.1 The Guidelines are intended to provide for chemical composition, delivery condition, mechanical properties, pitting corrosion resistance performance, list of products fit for carriage, and control of the construction process etc., in order to enable the safe operation of cargo tank boundary and process pressure vessels for oil, gas and water or other members of bulk chemical tankers constructed with lean duplex stainless steels during their target service life.

1.2 Application

1.2.1 The Guidelines are applicable to works approval and survey of lean duplex stainless steels manufactured in accordance with the requirements of CCS Rules for Materials and Welding.

1.2.2 The Guidelines apply to lean duplex stainless steels intended for use in the construction of cargo tank boundary, process pressure vessels for oil, gas and water as well as other members of bulk chemical tankers.

1.2.3 Lean duplex stainless steels are, in addition to the provisions of the Guidelines, to comply with the relevant requirements for hull structural steels in Chapter 3, PART ONE of CCS Rules for Materials and Welding .

1.3 Normative references

1.3.1 Chapters 2 and 3, PART ONE of CCS Rules for Materials and Welding.

1.3.2 W02 Rolled Stainless Steel Plates of CCS Guidelines for Survey of Marine Products.

1.3.3 J01 Welding Consumables of CCS Guidelines for Survey of Marine Products.

1.3.4 ASTM 1084-15a: “Standard Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels”.

1.3.5 ISO 5817: “Welding-Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections”.

1.4 Terms and definitions

1.4.1 For the purpose of the Guidelines, the terms used have the meanings defined in the following paragraphs:

(1) Lean duplex stainless steel: duplex stainless steel the Ni content of which in the chemical composition is less than 2.5%;

(2) Conventional duplex stainless steel: duplex stainless steel the Ni content of which in the chemical composition is not less than 2.5%;

(3) Pitting corrosion tests: tests that evaluate the pitting corrosion resistance performance of lean duplex stainless steels in 5% ferric chloride +1% sodium nitrate solution.

1.5 Testing and survey

1.5.1 All pitting corrosion tests are to be carried out by qualified personnel in laboratories recognized or accepted by CCS, using compliant testing appliances and in accordance with specified testing procedures.

1.5.2 Unless otherwise specified by the Guidelines, testing is to be carried out in accordance with the relevant provisions of PART ONE and PART THREE of CCS Rules for Materials and Welding.

1.6 Markings and certificates

1.6.1 Markings and certificates are to comply with the requirements for Section 1, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

CHAPTER 2 LEAN DUPLEX STAINLESS STEELS

2.1 General requirements

2.1.1 Unless otherwise specified by this Chapter, lean duplex stainless steels are to be manufactured in accordance with the relevant provisions of Chapter 3, PART ONE of CCS Rules for Materials and Welding.

2.2 Technical conditions for lean duplex stainless steels

2.2.1 The chemical composition of ladle samples of lean duplex stainless steels is to comply with the requirements of Table 2.2.1.

Chemical Composition of Lean Duplex Stainless Steels (％ by weight) Table 2.2.1

Grade	Chemical Composition (%)								
	C	Si	Mn	P	S	Cr	Ni	Mo	N
S32101	≤0.04	≤1.00	4.00-6.00	≤0.040	≤0.030	21.0-22.0	1.35-1.70	0.1-0.8	0.20-0.25

2.2.2 Lean duplex stainless steels are to be delivered in solid solution and the mechanical properties are to comply with the requirements of Table 2.2.2.

Mechanical Properties of Lean Duplex Stainless Steels Table 2.2.2

Grade	Mechanical Properties				Charpy V-notch impact test		
	Yield strength $Rp_{0.2}$ min (N/mm^2)	Tensile strength Rm min (N/mm^2)	Elongation A min (%)	Hardness① HB max	Test temperature(℃)	Impact value(J)	
						Long.	Trans.
S32101	450	620	25	293	-20	41	27

Note: ① The hardness test is not a compulsory test item.

2.2.3 For intercrystalline corrosion tests of lean duplex stainless stainless steel, specimen preparation and testing are to be in accordance with the requirements of Section 7, Chapter 2, PART ONE of CCS Rules for Materials and Welding. The requirements for batch tests in 3.5.4.1, Section 5, Chapter 3, PART ONE of CCS Rules for Materials and Welding are also to be complied with.

2.2.4 For pitting corrosion tests of lean duplex stainless stainless steel, specimen preparation and testing are to be in accordance with the requirements of Appendix A. The requirements for batch tests in 3.5.4.1, Section 5, Chapter 3 , PART ONE of CCS Rules for Materials and Welding are also to be complied with.

2.2.5 In case of actual loading demands from clients, product corrosion resistance tests of stainless steel are to be carried out in accordance with the relevant technical requirements and subject to CCS agreement.

2.3 Works approval of lean duplex stainless steels

2.3.1 Works approval of lean duplex stainless steels is to be carried out in accordance with Appendix B of the Guidelines.

2.4 Survey of lean duplex stainless steels

2.4.1 Unless otherwise specified by this Chapter, unit/batch inspection of lean duplex stainless steels is to be in accordance with W02 Rolled Stainless Steel Plates of CCS Guidelines for Survey of Marine Products.

2.5 Approval of welding procedures of lean duplex stainless steels

2.5.1 The application of approval of welding procedures is to be in accordance with the relevant requirements of Section 1, Chapter 3, PART THREE of CCS Rules for Materials and Welding and Section 1, Chapter 4 of CCS Guidelines for Inspection of Hull Welds.

2.5.2 Welding procedure approval tests are to be in accordance with the relevant requirements of 3.2.7.2, Section 2, as well as Section 3, Chapter 3, PART THREE of CCS Rules for Materials and Welding. The following requirements are also to be complied with.

(1) The diameter of the former and the angle of bend are to comply with the requirements of Table 2.5.2.

Diameter of the former and angle of the bend **Table 2.5.2**

Material	Diameter of the former	Angle of the bend
S32101	$4t$①	180°

Note: ① t is the specimen thickness.

(2) In pitting corrosion tests, specimens of butt welds are to be taken in accordance with the requirements of Appendix A of the Guidelines while specimen of fillet welds are to be taken based on the actual situation upon the agreement of CCS surveyors.

CHAPTER 3 APPLICATION OF LEAN DUPLEX STAINLESS STEELS

3.1 General requirements

3.1.1 Different from the application of conventional duplex stainless steel, this Chapter supplements the list of products fit for carriage and construction process requirements for lean duplex stainless steels.

3.2 List of products fit for carriage

3.2.1 For corrosive products in Chapters 17 and 18, PART THREE of the Rules for Construction and Equipment of Ships Carrying Dangerous Liquid Chemicals in Bulk, corrosion resistant tests are to be carried out in accordance with the recognized standards to verify their compatibility with tank boundary constructed of lean duplex stainless steels. Products listed in Table 3.2.1 have passed the corrosive resistant tests. It is also recommended that the compatibility with tank boundary constructed of lean duplex stainless steels remain to be tracked after operational service.

List of acidic/alkaline products fit for carriage by lean duplex stainless steels Table 3.2.1

No.1	Acetic acid
No.2	Acetic anhydride
No.3	Formic acid (85% or less acid)
No.4	Formic acid (over 85%)
No.5	Formic acid mixture (containing up to 18% propionic acid and up to 25% sodium formate)
No.6	Decanoic acid
No.7	Neodecanoic acid
No.8	Citric acid (70% or less)
No.9	Acrylic acid
No.10	Urea solution
No.11	Aluminium sulphate solution
No.12	Ammonium sulphate solution
No.13	Ammonium sulphide solution (45% or less)

No.14	Ammonium thiosulphate solution (60% or less)
No.15	Sodium hydrogen sulphite solution (45% or less)
No.16	Butyric acid
No.17	Pentanoic acid
No.18	n-Pentanoic acid (64%)/2-Methyl butyric acid (36%) mixture
No.19	Propionic acid
No.20	Propionic anhydride
No.21	Trimethylacetic acid
No.22	Sodium hydroxide solution (*)
No.23	1,3-Dichloropropene
No.24	Benzyl chloride

3.2.2 Except for the products listed in Table 3.2.2 that are unfit for carriage by tank boundary constructed of lean duplex stainless steels, other products in Chapters 17 and 18, PART THREE of the Rules for Construction and Equipment of Ships Carrying Dangerous Liquid Chemicals in Bulk are fit for carriage by tank boundary constructed of lean duplex stainless steels. It is also recommended that the compatibility of the above-mentioned products with tank boundary constructed of lean duplex stainless steels remain to be tracked after operational service.

List of acidic/alkaline products unfit for carriage by lean duplex stainless steels Table 3.2.2

No.1	Lactic acid
No.2	Aluminium choride/Hydrogen chloride solution
No.3	Ferric chloride solutions
No.4	Magnesium chloride solution
No.5	Polyaluminium chloride solution
No.6	Potassium chloride solution
No.7	Potassium chloride solution (less than 26%)

No.8	Chloroacetic acid (80% or less)
No.9	2- or 3-Chloropropionic acid 3-
No.10	2,2-Dichloropropionic acid
No.11	Phosphoric acid
No.12	Ammonium nitrate solution (93% or less)
No.13	Calcium nitrate/Magnesium nitrate/Potassium chloride solution
No.14	Chlorosulphonic acid
No.15	Ferric nitrate/Nitric acid solution
No.16	Fluorosilicic acid solution (20-30%)
No.17	Hydrochloric acid
No.18	Nitrating acid (mixture of sulphuric and nitric acids)
No.19	Nitric acid (70% and over)
No.20	Nitric acid (less than 70%)
No.21	Sulphuric acid
No.22	Sulphuric acid, spent

3.3 Supplementary requirements for lean duplex stainless steels during construction and operation

3.3.1 Lean duplex stainless steels are to be stored in isolation from carbon steel, and is usually required to be stored indoors to be protected against dust, moisture and water.

3.3.2 When lean duplex stainless steels are stacked, the layers of stacking and layout of pad woods are to be controlled, to avoid deformation and surface scratch of the material.

3.3.3 During transportation, all the fixtures and reinforcements in contact with lean duplex stainless steels are to be made of stainless steel. The lifting of stainless steels is to be steady and impact is strictly prohibited.

3.3.4 Special positioner is to be used in the infield construction. All the places in contact with lean duplex stainless steels are to be made of stainless steel, and the contact positions are to be rounded.

3.3.5 Specialized construction tools for stainless steels are to be used in the construction process, and use of carbon steel construction tools is strictly prohibited.

3.3.6 Welders engaged in the welding of lean duplex stainless steels are to have welder certification acceptable to CCS.

3.3.7 Welding consumables for lean duplex stainless steels are to comply with the relevant requirements of Chapter 2, PART THREE of CCS Rules for Materials and Welding and J01 Welding Consumables of CCS Guidelines for Survey of Marine Products.

3.3.8 The selection of welding consumables for lean duplex stainless steels are to take into consideration the requirements for chemical composition, mechanical properties and corrosion resistance. See Table 3.3.8 for the recommended welding consumables.

Welding consumables recommended for lean duplex stainless steels **Table 3.3.8**

Base material 2 / Grade / Base material 1	S32101	S30403 S30408	S31603 S31608	Low carbon steel and low alloy steel
S32101	2205	304L	316L	309

3.3.9 Lean duplex stainless steels is to be welded using approved welding procedures. In addition, the relevant requirements in Section 4, Chapter 5, PART THREE of CCS Rules for Materials and Welding are to be complied with.

3.3.10 After the completion of the segment structure consisting of lean duplex stainless steels, the welds, defects and contamination on the side of the cargo tank are to be ground and polished in time, and lime water is to be applied to protect it.

3.3.11 During the construction phase, all scaffolds in the cargo tanks are to be sanded, painted or galvanized, and the contact positions with lean duplex stainless steels are to be protected by wood or rubber.

3.3.12 Dye penetrant examinations of the contact surfaces between lean duplex stainless steels and products are to be in compliance with B-level required by ISO 5817 or other recognized standards.

3.3.13 The pickling and passivation procedures of lean duplex stainless steel liquid cargo tanks are to be carried out in accordance with the relevant requirements of the manufacturer and the ship operator.

APPENDIX A PITTING CORROSION TEST FOR LEAN DUPLEX STAINLESS STEELS

A1 General provisions

A1.1 The pitting corrosion test for lean duplex stainless steels is mainly used to evaluate the pitting corrosion resistance performance of lean duplex stainless steel products and weld joints.

A2 Test specimen

A2.1 An original surface of the specimen is to be kept as far as possible. For flat products, a specimen is recommended to be approximately 25 mm by 50 mm by (1.5 mm to 5.0 mm). Other product forms may be cut for test specimens convenient for testing. For weld joints, weld reinforcement is to be removed.

A2.2 Specimens are generally taken by machining. After the specimens are cut, any material that may have been affected by high temperature or deformation associated with the cutting is to be removed by machining or grinding prior to testing.

A2.3 Three specimens (stainless steel products and weld joints) are taken for each test set.

A2.4 All surfaces of the specimen are to be polished to a uniform finish using special sandpaper not less than 120 mesh . Polishing is to be performed slowly to prevent overheating.

A2.5 The dimensions of the specimen are measured, and the total exposed surface area is calculated.

A2.6 The specimen is to be cleaned, dipped in alcohol or acetone, and air dried.

A2.7 The specimen is to be weighed to the nearest 1 mg or better

A3 Test procedures

A3.1 The test solution is prepared by dissolving 55.1g g of reagent-grade ferric chloride, FeCl3·6H2O, and 6.6g sodium nitrate, $NaNO_3$, in 600 ml of distilled water (a mixed solution of approximately 5% FeCl3 +1% $NaNO_3$ by weight).

A3.2 Fill the test container with the required volume of at least 0.2 ml/mm^2 of the specimen surface area, submerge the specimen, transfer it to the constant temperature bath. Products and weld joints are to be heated to the the desired test temperature, i.e.25±1℃.

A3.3 Place the specimen in the glass cradle and immerse it in the test solution for 24 h once the temperature has been established. Cover the test container with a watchglass during the test period. Maintain the test temperature with an accuracy of ±1℃ throughout the test.

A3.4 At the end of the test, remove the specimen from the solution, rinse with water, remove corrosion products, dry and weigh the specimen to 1 mg or better.

A4 Test results

A4.1 No pitting attack is to be visible on the test face(s).

A4.2 Unless otherwise specified, the corrosion rate (i.e. weight loss per unit area after 24-hour immersion) is not to exceed 10 mdd. The corrosion rate is to be calculated as follows:

$$CR = \frac{W_1 - W_2}{S} \times 10^4$$

where: CR ——corrosion rate, in mdd;

W_1——specimen weight prior to test, in mg;

W_2——specimen weight after test, in mg;

S ——total surface area, in mm^2.

A4.3 The micro-structure of the specimen after the test is to comply with the requirements of Appendix 2 of ASTM 1084-15a.

A4.4 For the pitting corrosion test, the test is considered satisfactory if all three specimens pass the test. Where an individual test result in a group is unsatisfactory, two additional specimens are to be taken for each unsatisfactory test item. The results of both re-tests are to be satisfactory.

APPENDIX B WORKS APPROVAL FOR LEAN DUPLEX STAINLESS STEELS

B1.1 Unless otherwise specified by this Appendix, the approval for lean duplex stainless steels, including documents, type test program, test items, is to comply with the relevant provisions of Section 8, Chapter 3, PART ONE of CCS Rules for Materials and Welding and W02 Rolled Stainless Steel Plates of CCS Guidelines for Survey of Marine Products.

B2.1 Selection of typical products for type test

B2.1.1 The type test is to be carried out on the products with the maximum thickness of lean duplex stainless steel. If there are differences in smelting, rolling and heat treatment states of the products, the products produced in each different way are to be selected for the type test.

B2.1.2 The specimens for the type test are to be taken from the top and bottom ends of each ingot. Where mould cast is employed, ingots can be selected randomly, but specimens are to be taken from the top and bottom ends of each ingot.

B2.2 Type test items

B2.2.1 Type tests are to be carried out in accordance with the requirements in W02 Rolled Stainless Steel Plates of CCS Guidelines for Survey of Marine Products in addition to the corrosion test requirements in B2.2.2 of this Section.

B2.2.2 For base metals and weld joints of lean duplex stainless steel (the specimens may be taken from the test piece for welding property), intercrystalline corrosion tests are to be carried out in accordance with Section 7, Chapter 2, PART ONE of CCS Rules for Materials and Welding and pitting corrosion tests are to be carried out in accordance with Chapter 2 and Appendix A of the Guidelines.