GUIDANCE NOTES
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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR SURVEY OF CORROSION RESISTANT STEEL OF CARGO OIL TANKS IN CRUDE OIL TANKERS

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CONTENTS

CHAPTER 1 GENERAL

1.1 General requirements

1.1.1 The purpose of the Guidelines is to ensure that the structure of cargo oil tanks of crude oil tankers complies with the requirements of IMO MSC.289(87), using corrosion resistant steel as an alternative means of protection to improve corrosion resistance performance and achieve the target useful life of 25 years.

1.1.2 The capability of corrosion resistant steel to achieve its target useful life depends on the type, application, maintenance and inspection of steel. The actual useful life is not constant, depending on many varying elements, including application.

1.1.3 Unless otherwise provided in these Guidelines, corrosion resistant steel of cargo oil tanks in crude oil tankers is also to comply with the relevant requirements of Section 2 Normal Strength Hull Structural Steels and Section 3 Higher Strength Hull Structural Steels, Chapter 3, PART ONE of CCS Rules for Material and Welding and W01 Rolled Steel of CCS Guidelines for Survey of Marine Products. For example, AH36RCB corrosion resistant steel is to comply with the requirements for corrosion resistant steel of inner bottom plating in these Guidelines in addition to the requirements for AH36 steel.

1.2 Application

1.2.1 The Guidelines apply to crude oil tankers of 5,000 DWT and above.

1.2.2 The Guidelines apply to steel plates, flats, sections and bars with thicknesses not more than 50 mm.

1.3 Terms and Definitions

1.3.1 The terms and definitions used in the Guidelines are as follows:

(1) *Crude oil tanker* means a crude oil tanker defined in Regulation 1 of Annex I of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, refer to the crude oil tankers and crude oil/product oil carriers engaged in the trade of carrying crude oil in compliance with 1.11.1 and 1.11.4 of the International Oil Pollution Prevention Certificate (IOPP Certificate Form B).

(2) *Corrosion resistant steel of cargo oil tanks in crude oil tankers* (hereinafter referred to as corrosion resistant steel) means the corrosion resistance steel utilized as an alternative to protective coating of cargo oil tanks of crude oil tankers satisfying IMO MSC.289(87).

(3) *Target useful life* means the target value, in years, of the durability of a structure for which the means of corrosion protection or utilization of corrosion resistance material is designed.

(4) *Conventional steel* means the hull structural steels listed in Section 2 Normal Strength Hull Structural Steels and Section 3 Higher Strength Hull Structural Steels, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

(5) *Reference steel* means the steel used as a reference test piece in the corrosion test.

(6) *Upper deck corrosion test* means a test to verify the corrosion resistance performance of corrosion resistance steels used in upper deck areas of cargo oil tanks in crude oil tankers.

(7) *Inner bottom plating corrosion test* means a test to verify the corrosion resistance performance of corrosion resistance steels used in inner bottom plating areas of cargo oil tanks in crude oil tankers.

(8) *Parent grade steel* means the steel with the same grade of toughness as the corrosion resistant steel listed in Section 2 Normal Strength Hull Structural Steels and Section 3 Higher Strength Hull Structural Steels, Chapter 3, PART ONE of CCS Rules for Materials and Welding. For example, for AH36RCB corrosion resistant steel, the parent grade steel is AH36.

(9) *PSPC-COT* means IMO MSC.288 (87) Performance standard for protective coating for cargo oil tanks of crude oil tankers.

1.4 Test and Inspection

1.4.1 The manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to, for selection of test materials and the witnessing of tests and for verifying the precision of the testing equipment.

1.4.2 All corrosion tests are to be carried out by qualified personnel using test devices complying with requirements and according to specified test procedures at the laboratories meeting CCS approval requirements for corrosion test organizations (for requirements, refer to Appendix B of the Guidelines). If the laboratory provides evidence of the validity of its tests and meets at least the requirements of Appendix B10, and the surveyor is present at specific stages (e.g. at the beginning and sampling stages of the corrosion resistance test) to witness the test, corrosion resistance tests may be carried out in an unapproved laboratory subject to CCS agreement.

CHAPTER 2 WORKS APPROVAL FOR CORROSION RESISTANT STEEL

2.1 General Requirements

2.1.1 The manufacturer producing corrosion resistant steel is to submit an application to CCS for approval.

2.1.2 The corrosion resistant steels may be works approved according to the areas of application:

(1) lower surface of upper deck of cargo oil tank and its surrounding structures;

(2) upper surface of inner bottom plating of cargo oil tank and its surrounding structures;

(3) structures of both above (1) and (2) areas.

2.1.3 In addition to the corrosion test specified in the Guidelines, the works approval of corrosion resistant steel is to be carried out in accordance with the relevant requirements of W01 Rolled Steel of CCS Guidelines for Survey of Marine Products.

2.1.4 The corrosion tests are to be carried out based on the areas of application in accordance with the requirements of Appendix A of the Guidelines.

2.2 Steel Manufacturing

2.2.1 The corrosion resistant steel is to be manufactured by electric or basic oxygen process or other methods specially approved by CCS, and is to be in compliance with the relevant requirements of Section 1, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

2.2.2 The deoxidation method for each grade of corrosion resistant steels and their condition of supply are to meet the relevant requirements of Section 2 or Section 3, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

2.2.3 The steel is to be reasonably free from segregations and non-metallic inclusions, and is to be demonstrated as being free from internal and surface defects prejudicial to the use of the material for the intended application. The acceptance criteria for surface finish and procedures for the repair of defects are to meet the relevant requirements of Section 1, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

2.2.4 The thickness tolerances of corrosion resistant steels are to meet the relevant requirements of 3.1.3, Section 1, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

2.3 Application for Approval and Test Program

2.3.1 When a manufacturer applies for works approval, following information is to be submitted, in addition to the necessary information normally to be submitted for approval:

(1) A corrosion test program;

(2) Corrosion test equipment and test environment;

(3) Technical data related to acceptance criteria, for confirming corrosion resistance;

(4) Test procedures and acceptance criteria;

(5) The technical background explaining how the variation in added and controlled elements improves corrosion resistance: a relationship of all the chemical elements which affect the corrosion resistance of steel; the chemical elements added/controlled to achieve the required level of corrosion resistance are to be specifically verified for acceptance;

(6) The brand name and maximum thickness of corrosion resistant steel for which approval is requested;

(7) The applicable welding methods, welding consumables and relevant welding parameters.

2.3.2 CCS is to examine the test program and determine test requirements in accordance with the requested scope of approval. The inspections and tests to be witnessed by the Surveyor are to be confirmed in the test program. In addition to all tests necessary for conventional hull structural steels, the test items are to include the corrosion test specified in Appendix A of the Guidelines.

2.4 Approval Procedures

2.4.1 The corrosion resistant steels are to be approved according to their grades, conditions of supply and application areas respectively.

2.4.2 Normally, CCS Surveyor is to be present at specified stages to witness the relevant test items as required in the test program.

2.5 Approval of Corrosion Resistant Steel

2.5.1 The test is to be carried out according to the test program approved by CCS.

2.5.2 The number of casts and test samples selected are to be sufficient to make it possible to confirm the validity of interaction effects and/or the control range (upper limit, lower limit) of the elements which are added or intentionally controlled, for improving the corrosion resistance. Where agreed, this may be supported with data submitted by the manufacturer.

2.5.3 The corrosion test is to be in accordance with the requirements of Appendix A of the Guidelines.

2.5.4 For approval of corrosion resistant steels, the corrosion test is to cover welding joints using proper welding consumables, in addition to parent material.

2.5.5 In addition to the test requirements specified above, CCS may require additional tests in case of the followings:

(1) when CCS determines that the control range is set by the theoretical analysis of each element based on existing data, the number of corrosion resistance tests conducted in accordance with the Appendix A is too few to adequately confirm the validity of the control range of chemical composition affecting corrosion resistant performance;

(2) When CCS determines that the data of the corrosion resistance test result for setting the control range of chemical composition affecting corrosion resistant performance varies too widely;

(3) when CCS determines that the validity of the corrosion resistance test result for setting the control range of chemical composition affecting corrosion resistant performance is insufficient, or has some flaws;

(4) when CCS Surveyor has not attended the corrosion resistance tests for setting the control range of chemical composition, and CCS determines that additional testing is necessary in order to confirm the validity of the test result data; and

(5) when CCS determines that it is necessary, for reasons other than cases (1) to (4) above.

2.5.6 The chemical composition of the corrosion resistant steel is to meet the requirements for that of each parent grade steel in CCS Rules for Materials and Welding. Elements to be added for improving the corrosion resistance and for which content is beyond the scope of the Rules and not specified in the Rules are to be generally within 1% in total.

2.5.7 The test results are to meet the requirements as appropriate.

2.6 Corrosion Resistant Designation

2.6.1 According to the Guidelines, a corrosion designation is to be added after grade designation of the parent steel approved as corrosion resistant steel of cargo oil tanks in crude oil tankers according to its area of application:

for upper deck area of cargo oil tanks, RCU;

for inner bottom plating area of cargo oil tanks, RCB;

for both upper deck and inner bottom plating area of cargo oil tanks, RCW.

For example, the corrosion resistant steel meeting the relevant performance requirements of AH36 grade for higher strength hull structural steel specified in CCS Rules for Materials and Welding and being suitable for use in upper deck structure inside cargo oil tank of crude oil tanker is to be designated as “AH36-RCU”.

2.7 Certificate

2.7.1 After the test is completed, the manufacturer is to complete the approval test report and submit it to CCS. Where all test results meet the requirements, CCS will issue a works approval certificate.

2.7.2 The works approval certificate is to include the following:

(1) approval certificate No.;

(2) name of manufacturer;

(3) designation of corrosion resistant steel;

(4) range of chemical composition of approved steel (including weight of each element added or intentionally controlled for improving corrosion resistance);

(5) maximum thickness;

(6) steelmaking method, casting method and condition of supply;

(7) applicable welding process and welding consumables;

(8) restriction in application (if any);

(9) period of validity of approval.

CHAPTER 3 PRODUCT INSPECTION FOR CORROSION RESISTANT STEEL

3.1 General Requirements

3.1.1 All corrosion resistant steels are to be manufactured at manufacturers which have been approved by CCS.

3.1.2 Unless otherwise specified in the Guidelines, the corrosion resistant steels are to be inspected in accordance with the requirements for parent grade steel.

3.1.3 Corrosion test is not necessary during factory inspection.

3.1.4 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to within the manufacturing specifications. Where inadequate control leads to inferior quality of product, the manufacturer is to identify the cause and establish measures to prevent its recurrence, and issue a report and submit it to CCS. Where the affected product is required for further use by the manufacturer, corrosion test is to be carried out for each cast. The frequency of testing for subsequent products offered may be increased to gain confidence in the quality at the discretion of CCS.

3.2 Chemical Composition

3.2.1 The chemical composition of samples taken from each cast is to be analyzed by the manufacturer. The result is to meet the provisions of paragraph 2.5.6.

3.2.2 All ranges of chemical composition related to material corrosion resistance, as identified for approval, is to be strictly controlled.

3.2.3 The analysis report of chemical composition provided by the manufacturer will be accepted by CCS, however, check may be carried out as required by the Surveyor.

3.3 Mechanical Properties

3.3.1 Mechanical properties of the corrosion resistant steels approved by CCS are to be tested in production inspection in accordance with the requirements for the parent grade steel.

3.3.2 The test material selection, specimen preparation, number of specimens and test are to be in compliance with the relevant requirements of Chapter 2 and Chapter 3, PART ONE of CCS Rules for Materials and Welding.

3.3.3 The test results are to meet the relevant requirements for parent grade steel specified in Section 2 or Section 3, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

3.4 Retest

3.4.1 Retest and acceptance are to be carried out in accordance with the relevant requirements of Section 2, Chapter 1, PART ONE of CCS Rules for Materials and Welding, if the mechanical properties do not meet the relevant requirements.

3.5 Identification

3.5.1 The manufacturer is to adopt a system for the identification of ingots, slabs and pieces which will enable the material to be traced to its original cast. The Surveyor can be given full facilities for so tracing the material when required.

3.6 Branding

3.6.1 Every finished piece is to be clearly marked by the manufacturer in at least one place with CCS brand and the following particulars:

(1) name or trade mark of the manufacturer;

(2) designation for the grade of steel, including designation for corrosion resistance;

(3) specification;

(4) cast number and other number or abbreviation which will enable the whole steel production process to be traced;

(5) if required by the purchaser, his order number or other identification marks.

The above particulars and seal are to be encircled with paint or otherwise marked so as to be clearly legible.

3.6.2 Where a number of light materials are securely fastened together in bundles, the manufacturer may, subject to agreement of CCS, mark only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the mark may be attached to each bundle.

3.6.3 In the event that any material bearing CCS brand fails to comply with the requirements of mechanical test, the mark is to be completely removed by the manufacturer.

3.7 Certificate

3.7.1 The certificate of conformity for steels is at least to contain the following particulars:

(1) purchaser's name and order number, and if known, the hull number for which the material is intended;

(2) identification of the cast and, where appropriate, the test specimen number;

(3) mark of the manufacturer;

(4) brand name and specification of the material (with added designation for corrosion resistant steel);

(5) chemical composition;

(6) weight of each element added or intentionally controlled for improving corrosion resistance confirmed during approval;

(7) test results;

(8) condition of supply; and

(9) quality assurance of the manufacturer.

CHAPTER 4 APPLICATION OF CORROSION RESISTANT STEEL

4.1 General Requirements

4.1.1 This Chapter provides the special requirements for the use of corrosion resistant steels for cargo oil tanks in crude oil tankers during construction and service.

4.1.2 Unless otherwise specified in these Guidelines, the construction and operation of corrosion resistant steels are to meet the requirements for parent grade steel.

4.2 Areas of Application

4.2.1 To meet the requirements of Reg.3-11, Part A-1, Ch.II-1 of IMO SOLAS Convention and resolution MSC.289(87), the approved corrosion resistant steel is to be applied in the following areas (see Figure 4.2.1):

(1) Deckhead with complete internal structure, including brackets connecting to longitudinal and transverse bulkheads. In tanks with ring frame girder construction the under deck transverse framing to be protected down to level of the first tripping bracket below the upper faceplate.

(2) Longitudinal and transverse bulkheads to be protected to the uppermost means of access level. The uppermost means of access and its supporting brackets to be fully protected.

(3) On cargo tank bulkheads without an uppermost means of access the protection to extent to 10% of the tank's height at centerline but need not extend more than 3 m down from the deck.

(4) Flat inner bottom and all structure to height of 0.3 m above inner bottom to be protected.

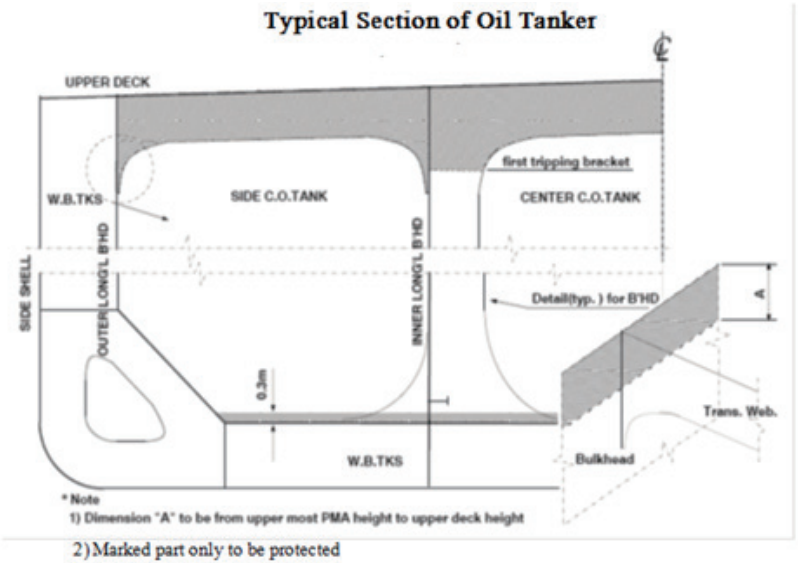

Figure 4.2.1 Scope of application of corrosion resistant steel for cargo oil tanks in crude oil tankers

4.2.2 Access arrangements provided for inspection that are integral to the ship structure, such as increased stiffener depths for walkways, stringers, etc., when located within the areas specified in 4.2.1, are to use corrosion resistant steel (in principle the manufacturer of the steel is same as that of the main structure) or be coated according to PSPC-COT.

4.2.3 Suitable corrosion resistant methods are to be provided for those portions of permanent means of access provided for inspection within the area specified in 4.2.1 that are not integral to the ship's structure, such as rails, independent platforms, ladders, etc. It is recommended to use corrosion resistant steel same as that used for the main structure or components and welds are to be coated according to PSPC-COT. Where other corrosion protection measures other than those stated above, for example cathodic protection are used, the performance of the corrosion resistant steel of the surrounding structure is not to be impaired.

4.2.4 It is also recommended that supports for piping, measuring devices, etc., be provided with corrosion resistant steel or protected by coating when located within the areas specified in 4.2.1.

4.3 Welding Consumables

4.3.1 For welding of corrosion resistant steel, the welding consumable on the certificate for corrosion resistant steel is to be applied, otherwise coating is to be carried out according to the requirements of 4.6.4.

4.3.2 If the welding consumables not indicated in the certificate are used, corrosion test of weld joints is to be carried out according to Appendix A in addition to the compliance with the requirements for welding consumables in Chapter 2, PART THREE of CCS Rules for Materials and Welding.

4.4 Corrosion Protection Methods

4.4.1 Different corrosion protection methods are allowed for use in the areas specified in 4.2.1, even combinations of different corrosion protection methods may also be applied to the same structural member.

Corrosion protection methods for cargo oil tanks of crude oil tanker

Table 4.4.1

Structural member		Upper deck	Inner bottom plating
Corrosion resistant method	Case 1	RCU	RCB
	Case 2	PSPC-COT	RCB
	Case 3	RCU	PSPC-COT
	Case 4	RCW	RCW

Notes: ① Corrosion resistant steel and coating protection may be applied to the same structural member.
② RCW may replace RCU or RCB.

4.4.2 Different corrosion protection methods are to comply with their respective standards.

4.4.3 Where the corrosion resistant steel is used for protection of cargo oil tank, the corrosion resistance of steel is to be suitable to the areas of application. Corrosion resistant steel with the same brand as that for main structure is to be used in the same area as far as possible.

4.5 Welding Procedures

4.5.1 The welding procedures for parent grade steel are applicable to the welding of the corrosion resistant steel of the same roughness grade.

4.6 Construction Stage

4.6.1 The corrosion resistant steels used for hull construction are to be approved and applied according to the permitted scope of application stated in certificates.

4.6.2 When two corrosion resistant steels with different brands are welded together within areas specified in 4.2.1, coating is to be carried out in weld areas, including the adjacent base metals with the minimum width of 100 mm according to PSPC-COT, see Figure 4.6.2. However, if the welding consumable on the approval certificate for the corrosion resistant steels is compatible with these two types of corrosion resistant steels, coating is not necessary.

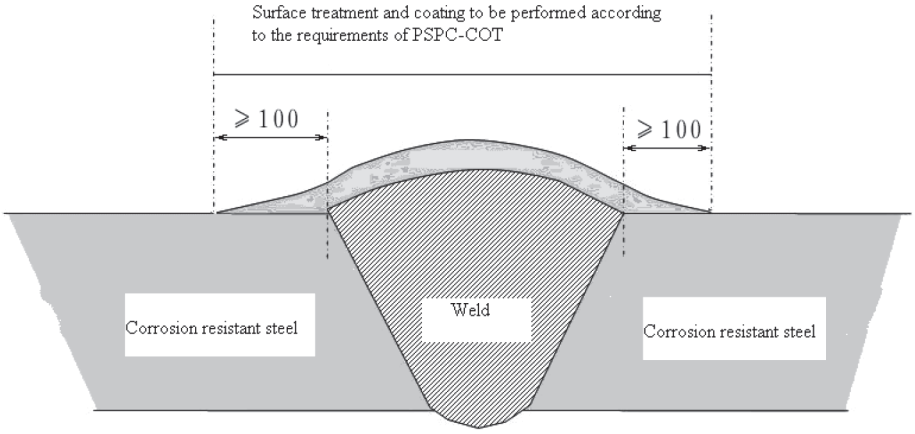

Figure 4.6.2 Welding between different corrosion resistant steels

4.6.3 Where the corrosion resistant steel is welded to conventional steel, the conventional steel and welds at the welded connection are to be coated and the coating is to be extended to cover corrosion resistant steel with a width not less than 100 mm according to PSPC-COT (see Figure 4.6.3).

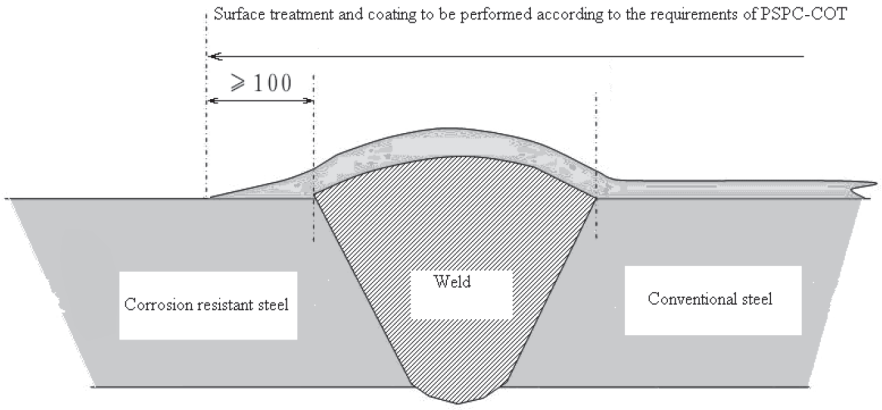

Figure 4.6.3 Welding of corrosion resistant steel to conventional steel

4.6.4 When the welding consumables not indicated in approval certificates are used, coating is to be carried out in weld areas, including the adjacent base metals with the minimum width of 100 mm according to PSPC-COT, see Figure 4.6.4.

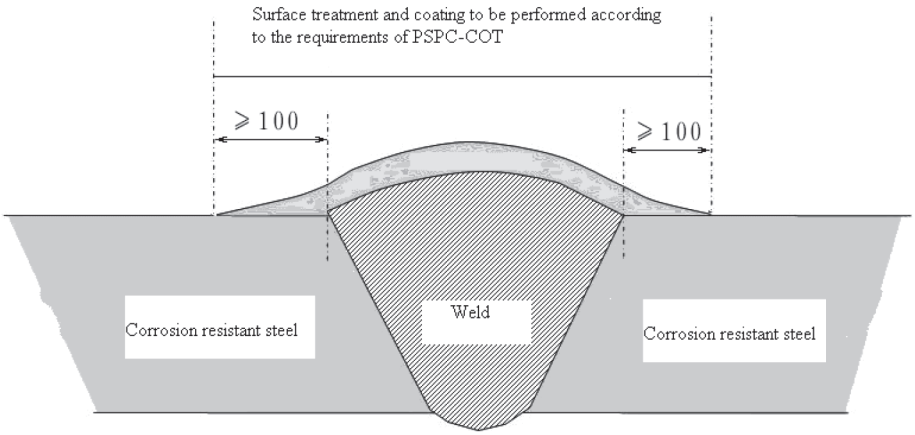

Figure 4.6.4 Welding consumables not indicated in approval certificates are used

4.6.5 Heat input of welding of corrosion resistant steel is to be not greater than allowable maximum welding heat input confirmed by approval test.

4.6.6 During the hull construction, it is to avoid harmful effects on the surface of corrosion resistant steel as far as possible. If necessary, proper measures may be taken to prevent the effects of splashing, arc striking, scoring, etc. on surface.

4.6.7 Where a temporary structure of conventional steel, such as hanging pieces, is required to be fitted on corrosion resistant steel structure or welding consumables not indicated on the approval certificate of corrosion resistant steel are used during construction of the ship, it is recommended that coating is to be applied on welds according to PSPC-COT, see Figure 4.6.7.

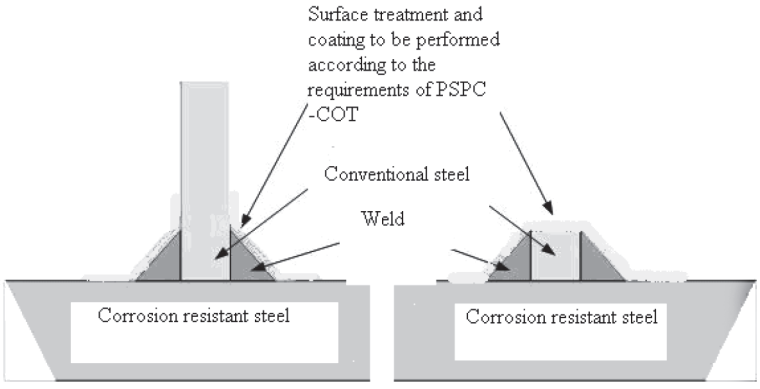

Figure 4.6.7 Range of coating for temporary structure on corrosion resistant steel

4.7 In-service stage

4.7.1 If the repair method is described in the Technical File, repairs are to be carried out in accordance with the said method.

4.7.2 If any structural member needs to be replaced, this is to be carried out by the recommended methods described in the technical file;

4.7.3 Where corrosion resistant is used to replace corrosion resistant steel, the steel with the same brand for construction is to be applied; welding area between two different corrosion resistant steels is to be coated according to PSPC-COT with the range indicated in Figure 4.6.2. However, if the welding consumable used is on the approval certificate for the corrosion resistant steels, coating is not necessary.

4.7.4 Where convention steel is used to replace corrosion resistant steel, coating is to be carried out according to PSPC-COT.

4.7.5 Where welding consumables not indicated in approval certificates are used, coating is to be carried out according to PSPC-COT with the range indicated in Figure 4.6.4.

4.8 Technical File

4.8.1 The shipbuilder is to prepare and submit the Technical File to CCS. If the applicable corrosion protection method varies for different locations, the information required for the technical file is to include each location and corrosion protection method separately. The Technical File is at least to include the following:

(1) copy of works approval certificate of corrosion resistant steel;

(2) brand and thickness, position/area of application of corrosion resistant steel (if such information has been marked on the approved drawings, the relevant drawings are also to be placed in the technical file);

(3) local area of application of coating and coating material (if any);

(4) welding consumables and approved welding procedure for corrosion resistant steel;

(5) repair method recommended by corrosion resistant steel manufacturer (if any).

4.8.2 A duplicated copy of the technical file confirmed by CCS is to be kept on board the tanker throughout its life of service.

4.8.3 When the tanker has been repaired, such as replacement of corrosion resistant steel, repair by welding for pitted locations, coating on the corrosion resistant steel structures, etc., the following information related to repair is to be recorded by shipowner or operator, and kept in the technical file:

(1) repaired locations;

(2) repairing method (repair by welding, replacement of corrosion resistant steel or coating applied);

(3) record of corrosion resistant steel (brand and plating thickness), welding consumables (brand and welding method) and welding procedure where corrosion resistant steel is replaced;

(4) record according to PSPC-COT where coating is applied.

Note 1: Details of coating on repairs to corrosion resistant steel are to be recorded in the Corrosion Resistant Steel Technical File. In such cases, duplicates of these coating records do not need to be included in the Coating Technical File.

Note 2: In case weld repairs of pitted parts are required, only welding consumables approved for the relevant corrosion resistant steel are to be used. If non-approved welding consumables are used, an appropriate area around the repaired part is to be coated suitably after the repairs in accordance with PSPC-COT.

Note 3: The thickness measurement records of regular survey are to be kept in documents specified by CCS and do not need to be recorded in the Corrosion Resistant Steel Technical File.

Appendix A
Test Procedures for Corrosion Resistance of Corrosion Resistant Steel for Cargo Tanks in Crude Oil Tankers

A1 Scope

The Procedures provides the test procedure for corrosion resistance performance of corrosion resistant steel for cargo tanks in crude oil tankers.

A2 Testing

Corrosion resistance performance of corrosion resistant steel is to be verified by the following tests.

A2.1 Test on simulated upper deck conditions

A2.1.1 Test device

A2.1.1.1 The diagram of the test device is shown in Figure A2.1.1.1. It is allowable to increase diameter appropriately to 390 mm on the basis of Figure A2.1.1.1 so as to hold 25 specimens. If further diameter increase is needed to hold more specimens, it is to be agreed by CCS.

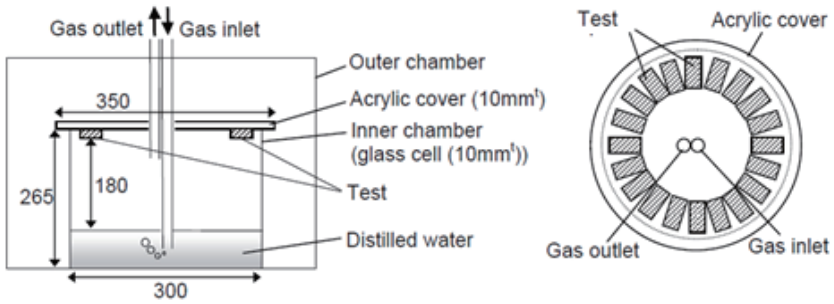

Figure A2.1.1.1 Diagram of simulated corrosion test device for upper deck

A2.1.1.2 The test device consists of a double chamber, and the temperature of the outer chamber is to be controlled. The ambient temperature around the test device is to be controlled as far as possible. The test device is to be capable of automatic temperature controlling, measuring and recording.

A2.1.1.3 The top cover of the upper deck test device is to be provided with reliable specimen fixture, which will not affect the tested surface of specimen.

A2.1.2 Test gas

A2.1.2.1 The ratio of gas mixture of simulated upper deck conditions in cargo oil tank is (4 ± 1% O_2 – 13 ± 2% CO_2 – 100 ± 10 ppm SO_2 – 500 ± 50 ppm H_2S – 83 ± 2% N_2).

A2.1.2.2 During the test, the following two groups of gases are to be mixed with same volume to enter into the vessels:

(1) (8±2)% O_2, (26±4)% CO_2, (200±20)ppm SO_2, N_2 balance;

(2) (1,000±100) ppm H_2S and N_2 balance.

A2.1.3 Test pieces

A2.1.3.1 The base metal test is to include 20 corrosion resistant steel base metal test pieces, and the welded joint test is to include 5 corrosion resistant steel welded joint test pieces. For comparison, at least five test pieces of reference steel are to be tested in the same condition.

A2.1.3.2 The chemical composition of reference steel is to be in compliance with the requirements of Table A2.1.3.2 and to be based on that of ladle analysis given in the mill certificate. The hull structural steel is to be selected as reference steel and steel complying with a national standard that meets the requirements of Table A2.1.3.2 is also acceptable.

Chemical composition for reference steel (%) Table A2.1.3.2

C	Mn	Si	P	S
0.13 ~ 0.17	1.00 ~ 1.20	0.15 ~ 0.35	0.010 ~ 0.020	0.002 ~ 0.008
Al (acid soluble min)	Nb. max	V max	Ti max	Nb + V + Ti max.
0.015	0.02	0.10	0.02	0.12
Cu max.	Cr max.	Ni max.	Mo max.	Other max.
0.1	0.1	0.1	0.02	0.02 (each)

A2.1.3.3 The size of each test piece is (25 ± 1) mm x (60 ± 1) mm × (5 ± 0.5) mm. The size of the test piece for a welded joint is (25 ± 1) mm × (60 ± 1) mm × (5 ± 0.5) mm, including (15 ± 5) mm width of the weld metal part, as shown in Figure A2.1.3.3. The scantlings of specimen may be measured accurately by micrometer or microcaliper, and the precision is 0.01 mm.

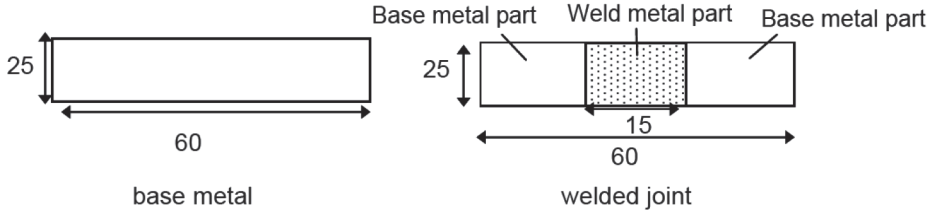

Figure A2.1.3.3 Test piece of this test

A2.1.3.4 For the specimen with excessive thickness, the thickness may be reduced from the back of the test surface to 5 mm ±0.5 mm by machining. Chamfering is not allowed in way of the edge of specimen.

A2.1.3.5 The tested surface of base metal is to be taken from a position within 2 mm of one rolled surface. The tested surface of all specimens (including reference steel) is to be polished by hand with an emery paper 600 # or grinded by machine before test. Roughness of all specimens is to be almost the same. It is recommended that the roughness of polished surface reach Ra 0.16μm.

A2.1.3.6 The base metal for welded joint specimen is to be taken from the same cast as that used for base metal test and they are allowed to be taken from different plates. The specimen is to be welded in the downhand position by the process and consumables to be approved for use with the base metal. The width of weld, excluding heat affected zone, is to be of 10 ~ 20 mm. The tested surface is to be polished by hand with an emery paper 600 # or grinded by machine before test. Roughness of all specimens is to be almost the same. It is recommended that the roughness of polished surface reach Ra 0.16μm.

A2.1.3.7 The specimen is to be washed by acetone and absolute ethyl alcohol in turn and dried by air blower, each specimen is to be weighed respectively and recorded. The weighing precision is 0.1mg. Then the specimen is to be placed in dry container for use.

A2.1.3.8 The specimen surface not to be tested is to be protected from corrosive environment in order not to affect the test results, such as the use of coating which is capable of resisting test corrosion medium and will not affect test result.

A2.1.3.9 All specimens are to be marked for easy identification by proper means which is easily to be identified and not to affect the test results.

A2.1.4 Test procedure

A2.1.4.1 Corrosion resistant steel specimens and reference steel specimens are to be located in one vessel.

A2.1.4.2 The tests for base metal are to be carried out for 21, 49, 77 and 98 days. The tests for reference steel are to be carried out for 98 days. The tests for welded joints are to be carried out for 98 days.

A2.1.4.3 There are to be five test pieces for each test period.

A2.1.4.4 It is to be confirmed that the corrosion rate of reference steel at the test device and conditions satisfies the criteria for evaluation, before commencement of corrosion test.

A2.1.4.5 All specimens are to be installed in place and at a basically equivalent distance to air outlet pipe (shown in Figure A2.1.1.1) before commencement of test, and each group of specimens is to be placed according to the principle of even distribution on the circumference. A sufficient distance between the surface of the specimen and the distilled water is to be kept to avoid splashing of distilled water. A certain clearance is to be kept between specimens. After the specimens are installed in place, the entire test plane is to be adjusted to horizontal position.

A2.1.4.6 The air inlet pipe is to be submerged in distilled water of vessel, and the end of air pipe is to be about 40 mm away from vessel bottom. In order to avoid excessive water level lowering due to water evaporation during test, distilled water is allowed to be supplemented properly during sampling.

A2.1.4.7 The test pieces is to be heated for 19 ± 2 h at 50 ± 2℃ and 3 ± 2 h at 25 ± 2℃ and the transition time is to be at least 1 h. The time for 1 cycle is 24 h. The temperature of the distilled water is to be kept at not higher than 36℃ . The transition time of heating/cooling temperature means the time from the beginning of heating/cooling to the required stable temperature, see Figure A2.1.4.7a and Figure A2.1.4.7b. The time difference of the same transition stage (such as cooling stage, insulating stage or heating stage) is not to be more than 10 min. During the whole test process, the temperatures of specimen and water are to be continuously recorded at intervals generally not exceeding 2.5 min.

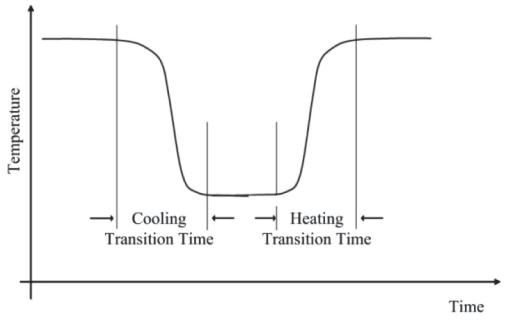

Figure 2.1.4.7a Transition time of temperature

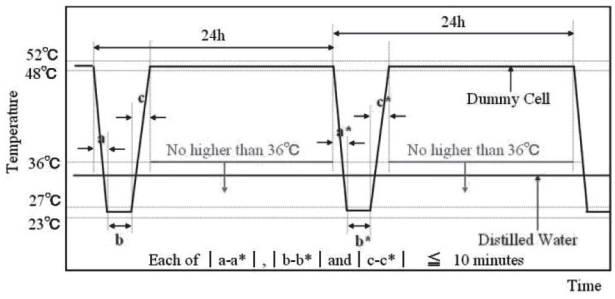

Figure2.1.4.7b Control of transition time

A2.1.4.8 During the process of test, the gases of two groups of different compositions specified in A2.1.2 are to be mixed with same volume, and then filled into test vessel. It is recommended that the gas flow rate within 24 h after commencement of test be controlled according to Table A2.1.4.8, and the subsequent gas flow rate is to be controlled not less than 20 ml/min.

Control of corrosive gas flow rate within 24h after commencement of test (including specimen replacement) Table 2.1.4.8

Inner diameter of test vessel (mm)	300	390
Range of gas flow rate (ml/min)	100~110	100~170

A2.1.4.9 Where the specimen needs to be taken out/replaced during the test, corrosion gas in the test device is to be blown off by a proper amount of pure nitrogen (N2) after test gas is shut down when the specimen is within the high temperature period, then, the specimen is to be taken out/ replaced after it is dried. The time of taking out/replacing the specimen is normally not to exceed 4 h. When nitrogen is displaced, its flow rate is preferably not to be less than 300 ml/min. The test gas and flow rate are to be re-controlled in accordance with the requirements of A2.1.4.8 after new specimen is placed to establish the corrosion environment.

A2.1.4.10 The corrosion resistant steel specimen for base metal test is to be taken out after 21, 49, 77 and 98 days respectively, and the specimen is to be taken out according to the principle of even distribution.The reference steel specimen is to be taken out after 98 days. The welded joint specimen is to be taken out after 98 days.

A2.1.4.11 The specimens taken out are to be treated as follows:

(1) The specimen taken out is to be scrubbed with a brush under running water to remove the corrosive. The residual corrosive on the surface is to be removed with the C3.1 solution of Appendix in ISO 8407-2009 or the C.3 acid lotion in Table A in GB/T 16545-2015;

(2) Proper solutions or tools are to be applied to remove the painting or coating on the specimen surface not to be tested;

(3) The specimen is to be wiped by acetone or absolute ethyl alcohol and dried.

A2.1.4.12 Each dried base metal specimen is to be weighed to an accuracy of ±1 mg.

A2.1.4.13 For welded joint specimen after being dried, two full thickness welded joint specimens approximately 20 mm × 5 mm wide are to be prepared. The principle axis of the specimen is to be perpendicular to the weld fusion line, and the weld fusion line is to be located approximately at its mid length, as shown in Figure A2.1.4.13. The specimens are to be mounted in resin to allow polishing of the cross section. The specimens are to be etched in Nital after polishing to reveal the fusion boundary. The surface to be tested is to be observed by a photomicrograph with approximately 100 times magnification for evaluation. Where angle calculation is needed for evaluation, an additional photomicrograph with approximately 250 times magnification is required.

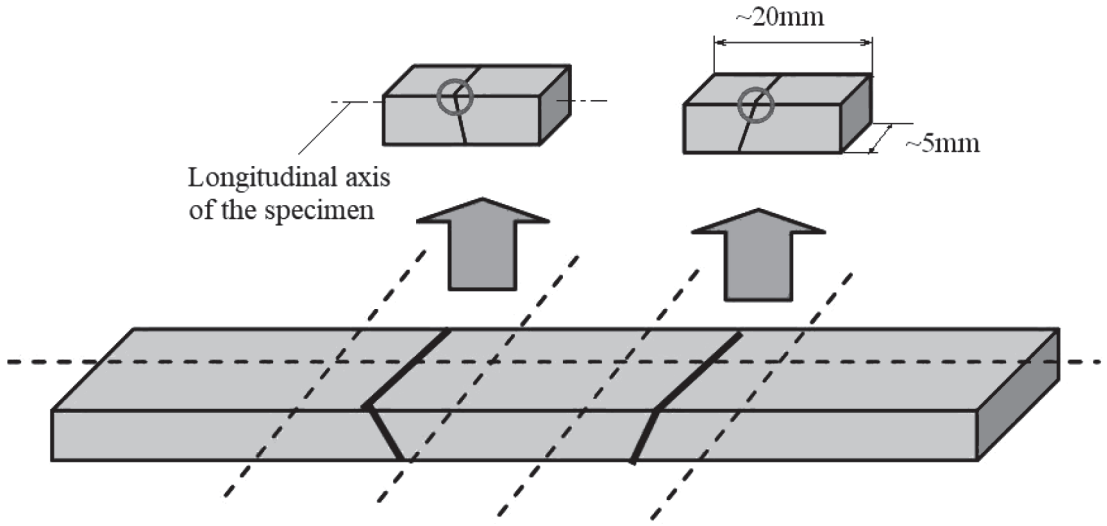

Figure A2.1.4.13 Welded joint specimen

A2.1.5 Test results

A2.1.5.1 Test results of base metal

(1) The size and weight of test piece are to be measured prior to testing.

(2) The weight loss (difference between initial weight and weight after testing) of reference steel (W_c) and corrosion resistant steel (W_{21}, W_{49}, W_{77} and W_{98}) is to be measured after testing.

(3) The corrosion loss of reference steel (CL_C) and corrosion resistant steel (CL_{21}, CL_{49}, CL_{77} and CL_{98}) is to be calculated by the following formulae:

$$CL_C(mm) = \frac{10 \times W_C}{S \times D}$$
$$CL_{21}(mm) = \frac{10 \times W_{21}}{S \times D}$$
$$CL_{49}(mm) = \frac{10 \times W_{49}}{S \times D}$$
$$CL_{77}(mm) = \frac{10 \times W_{77}}{S \times D}$$
$$CL_{98}(mm) = \frac{10 \times W_{98}}{S \times D}$$

where: W_C — weight loss of reference steel (g) (average of five test pieces)
W_{21} — weight loss of corrosion resistant steel after 21 days (g) (average of five test pieces)
W_{49} — weight loss of corrosion resistant steel after 49 days (g) (average of five test pieces)
W_{77} — weight loss of corrosion resistant steel after 77 days (g) (average of five test pieces)
W_{98} — weight loss of corrosion resistant steel after 98 days (g) (average of five test pieces)
S — surface area (cm^2)
D — density (g/cm^3).

The test is considered to be carried out appropriately if the CL_C of at least 3 of the 5 reference steel specimens is between 0.05 and 0.11 (corrosion rate is between 0.2 and 0.4 mm/year). Otherwise, the test conditions are to be adjusted to meet the requirements of CL_C.

(4) The coefficients A and B are to be calculated from the test results for 21, 49, 77 and 98 days by least square method.

Corrosion loss of corrosion resistant steel is described as follows:

$$CL = A \times t^B$$

where: A (mm) and B — coefficient
t — test period (days);

(5) The estimated corrosion loss after 25 years (ECL) is to be calculated by the following formula:

$$ECL \text{ (mm)} = A \times (25 \times 365)^B$$

A2.1.5.2 Test results of welded joint

(1) The depth of step is to be calculated as follows, as shown in Figure A2.1.5.2(1):

(a) On the photomicrograph, construct a line A-B, perpendicular to the corrosion surface through the point where fusion line and the corrosion surface cross;

(b) Construct two parallel lines D-C and E-F through line A-B from upper and lower steps and extending at least 300 μm along the base metal and weld metal side respectively;

(c) Measure the distance r mm between the intersection point at line A-B and line C-D and between line A-B and line E-F;

(d) If the intersection point of line E-F and line A-B is above that of line C-D and line A-B, the existence of step is to be neglected and the test is considered satisfactory.

(e) If the intersection point of line E-F and line A-B is not above that of line C-D and line A-B, the depth R of discontinuous steps is to be calculated by the following formula:

$$R = \frac{r \times 1000}{M} \ \mu m$$

where: r — measured depth of step, in mm;
M — magnification of photomicrograph.

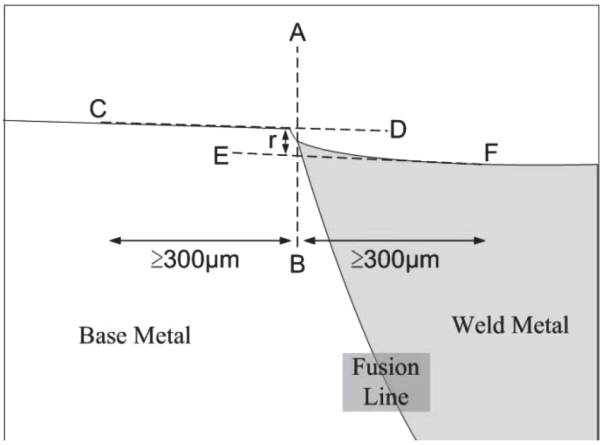

Figure A2.1.5.2(1) Measurement for depth of step

(2) Measurement for angle of step according to (3) below is unnecessary if the depth of step calculated on both samples is not greater than 30 μm or if either step exceeds 50 μm for a single specimen.

(3) The angle of step is to be calculated as follows, as shown in Figure A2.1.5.2(3):

(a) Produce a photomicrograph at a magnification of approximately 250 times;

(b) Draw an average surface line C-D for base metal part and E-F for weld metal part.

(c) Find the closest intersection point with the step of the base metal surface profile and the constructed line C-D and the closest intersection point with the step for weld metal constructed line E-F respectively, and connect those two intersection points.

(d) Measure the angle given by the line C-D and the connected line described in (c).

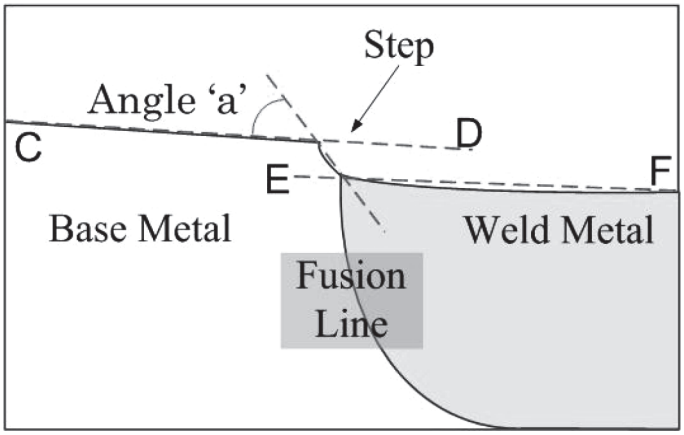

Figure A2.1.5.2(3) Calculation of step angle

A2.1.6 Acceptance Criteria

A2.1.6.1 For base metal test results, ECL(mm) is to be less than or equal to 2 mm;

A2.1.6.2 There is to be no discontinuous surface between the base metal and weld metal for welded joint. Five welded joint specimens are to meet the following conditions, otherwise, or it is regarded that the welded join contains discontinuous surface:

(1) The depths of both steps of each welded joint specimen are less than or equal to 30 μm, or

(2) The depths of both steps of each welded joint specimen are less than or equal to 50 μm and in addition, both the measured angles are less than or equal to 15°.

A2.1.7 Test Report

A2.1.7.1 The test report is to include the following information:

(1) name of the manufacturer;

(2) date of tests;

(3) brands of corrosion resistant steel and welding consumables;

(4) test results according to A2.1.5;

(5) judgement according to A2.1.6.

A2.2 Test on simulated inner bottom conditions

A2.2.1 Test device

A2.1.1.1 The test device is shown in Figure A2.2.1.1.

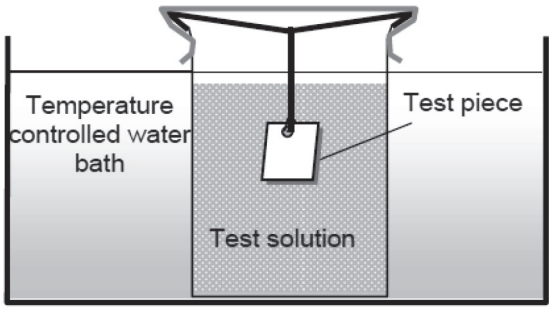

Figure A2.2.1.1 Diagram of simulated corrosion test apparatus for inner bottom

A2.2.2 Test pieces

A2.2.2.1 There are to be at least five test pieces for base metal and welded joint, respectively. For comparison, at least five test pieces of reference steel specimens are to be tested in the same condition. The reference steel specimens are to comply with the requirements of A2.1.3,2.

A2.2.2.2 The size of each test piece is 25 ± 1 mm × 60 ± 1 mm × 5 ± 0.5 mm for a specimen with base metal only, and is 25 ± 1 mm × 60 ± 1 mm × 5 ± 0.5 mm for a specimen with welded joint including 15 ± 5 mm width of weld metal part as shown in Figure A2.2.2.2.

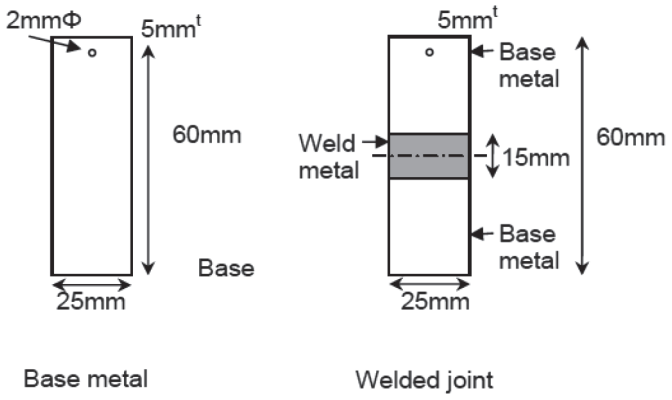

Figure A2.2.2.2 Test piece for simulated inner bottom conditions

A2.2.2.3 The test pieces are to be prepared in accordance with A2.1.3.4-A2.1.3.7.

A2.2.3 Test solution

A2.2.3.1 The test solution contains 10 mass% NaCl and its pH is 0.85 adjusted by HCl solution (If the pH after dilution is measured, the pH after dilution is to be equal to pH0.85 before dilution).

A2.2.3.2 The test solution is to be changed to a new one every 24 h to minimize pH change of the test solution.

A2.2.3.3 The volume of the solution is more than 20ml/cm2 (surface area of test piece).

A2.2.3.4 The temperature of the test solution is to be kept at 30 ± 2℃ .

A2.2.3.5 In order to prevent the tested solution from evaporating, vessels are to be covered by plastic film or other appropriate sealing material.

A2.2.4 Test procedure

A2.2.4.1 When the inner bottom plating is tested, the sealing on the solution vessel is to be uncovered. The specimen with thin nylon cord (0.3 mm to 0.4 mm in diameter) is hung in the center of vessel. Each specimen may be either placed in a different vessel respectively, or several specimens of same material may be placed in one vessel. The ratio of test corrosion medium volume and specimen is not to be less than the required ratio. Where several specimens are placed in one vessel, the interval between specimens is generally not less than 30 mm.

A2.2.4.2 The vessels are to be sealed during the test in order to prevent the solution from evaporating and concentrating.

A2.2.4.3 The test solution is to be changed to a new one every 24 h. The test solution is not to be reused.

A2.2.4.4 The test is to be carried out for 72 h for base metal, and 168 h for welded joint.

A2.2.4.5 After the completion of the test, the test pieces are to be treated in accordance with A2.1.4.11-A2.1.4.13.

A2.2.5 Test results

A2.2.5.1 Test results of base metal

(1) The size and weight of test piece are to be measured prior to testing;

(2) The weight loss (difference between initial weight and weight after testing) of test piece is to be measured after testing;

(3) The corrosion rate (*C.R.*) is to be calculated by the following formula:

$$C.R(mm\ /\ year) = \frac{365(days) \times 24(hours) \times W \times 10}{S \times 72(hours) \times D}$$

where: W — weight loss (g);
S — surface area (cm^2);
D — density (g/cm^3);

(4) The *C.R.* is to be plotted on a normal distribution statistic chart to identify specimen which hold crevice and/or localized corrosion. *C.R.* data which deviate from the normal statistical distribution must be eliminated from the test results. An example is shown in Figure A2.5.1(4) for reference.

(5) The average of C.R.'s data ($C.R._{ave}$) is to be calculated:

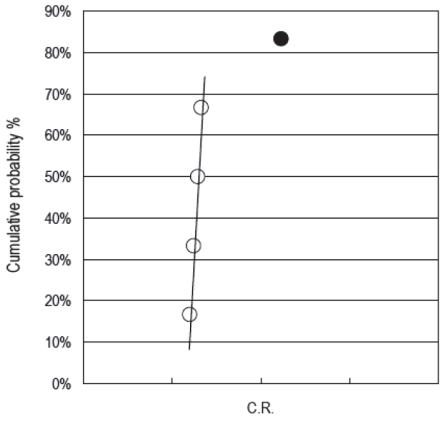

Figure A2.2.5.1(4) Diagram of plot of C.R.s on a normal distribution chart (In this case C.R. data • should be abandoned and eliminated)

A2.2.5.2 Test results of welded joint

(1) The surface boundary between base metal and weld metal is to be measured in accordance with A2.1.5.2.

A2.2.6 Acceptance criteria

A2.2.6.1 $C.R._{ave}$ (mm/year) ≤ 1.0 (for base metal);

A2.2.6.2 There is to be no discontinuous surface between the base metal and weld metal for welded joint.

A2.2.7 Test Report

A2.2.7.1 The test report is to include the following information:

(1) name of the manufacturer;

(2) date of tests;

(3) brands of corrosion resistant steel and welding consumables;

(4) test results according to A2.2.5;

(5) judgement according to A2.2.6.

Appendix B
Requirements for Approval of Laboratories Testing Corrosion Resistance of Corrosion Resistant Steel

B1 Scope

The requirements are applicable to approval of laboratories testing corrosion resistance of steel used for upper deck and inner bottom plating of cargo oil tanks of crude oil tankers (hereinafter referred to as laboratories) according to IMO Resolution MSC.289(87) Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers.

B2 Approval basis

1) IMO Resolution MSC.289(87) Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers

2) CCS Guidelines for Approval of Institutions of Testing and Inspection for Marine Products

B3 General requirements

B3.1 Unless otherwise provided by this Appendix, the laboratory is to meet the requirements of Part One of CCS Guidelines for Approval of Institutions of Testing and Inspection for Marine Products.

B3.2 The laboratory is to have necessary specimen processing and handling capability.

B3.3 Test gas used by the laboratory is to meet the requirements of quality and have the quality certificate.

B3.4 The laboratory is to have devices which can automatically record temperature.

B3.5 The laboratory placing the upper deck test device is to be provided with exhaust gas treatment equipment and gas leakage alarm unit, and the exhaust emission is to meet the relevant national provisions.

B4 Documents

B4.1 The laboratory is to submit following documents in addition to the information required in 3.2 of Chapter 3, Part One, CCS Guidelines for Approval of Institutions of Testing and Inspection for Marine Products:

1) History of carrying out corrosion test of corrosion resistant steel;

2) Source and composition of reference steel used for test;

3) Details of gases and chemical medicine mainly used for test.

B5 Test equipment

B5.1 The laboratory is at least to have following qualified test equipment and material:

No.	Equipment name	Quantity	Application
1	Electronic analytical balance (precision not lower than 0.1mg)	1	Measuring corrosion weight loss
2	Metallographic polishing machine	1	Specimen polishing
3	Micrometer or vemier caliper (precision not lower than 0.01mm)	1	Specimen dimension measurement
4	Temperature and humidity measuring instruments	2	Measuring temperature and humidity
5	Quality and flow control meter (precision not lower than 1 ml/min)	2	Gas flow control
6	H2S detector	2	Detecting H2S content in the air (at least 1 detector is a fixed type provided with alarm function)
7	SO_2 detector	1	Detecting SO_2 content in the air
8	Metallographic microscope	1	Microstructure observation
9	Testing apparatus for corrosion of upper deck of cargo oil tank	1	Corrosion test
10	Testing apparatus for corrosion of inner bottom plating of cargo oil tank	1	Corrosion test
11	pH meter	1	Measuring pH value
12	Comparison steel material meeting IMO requirements for standard components	Some	Verifying effectiveness of test

B6 Documents provided in the laboratory

B6.1 The laboratory is to be provided with following technical documents:

1) Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (IMO Resolution MSC.289(87));

2) CCS Guidelines for Survey of Corrosion Resistant Steel of Cargo Oil Tanks in Crude Oil Tankers;

3) Relevant national provisions, self-developed regulations and operational guidelines involving personnel protection against toxic and hazardous gas as well as waste gas and liquid handling.