Guideline No.: W-08 (202011)

W-08

STEEL FOR ANCHOR CHAIN CABLES AND ACCESSORIES

Issued date: November 30, 2020

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.

Historical versions and release date : W-08 (201510) 2015-10-20

W-08 (201610) 2016-10-20

W-08 (201707) 2017-07-04

Main changes:

1、 The requirements intended for R6 mooring chains/accessories steels is added to this guideline.

CONTENTS

STEEL FOR ANCHOR CHAIN CABLES AND ACCESSORIES

1 Application

1.1 This Guideline applies to the works approval and products inspection of steel and its semifinished product both for anchor chain cables and accessories onboard ships and for mooring chain cables and accessories onboard offshore installations, which are manufactured in accordance with the requirements of CCS Rules for Classification of Sea-Going Steel Ships and CCS Rules for Materials and Welding.

1.2 The steel intended for anchor chain cables and accessories include rolled steel bars, forgings and castings in the guideline.

1.3 The steel intended for anchor chain cables and accessories are subdivided into eight grades, i.e. M1, M2 and M3 for marine anchor cables/accessories steel and MR3, MR3S, MR4, MR4S , MR5 and MR6 for mooring chains/accessories steels, depending on the nominal tensile strength and applicable product types.

2 Normative references

(1) CCS Rules for Classification of Sea-Going Steel Ships;

(2) CCS Rules for Materials and Welding;

(3) IACS UR W22 Offshore Mooring Chain

(4) IACS UR W18 Anchor Chain Cables and Accessories Including Chafing Chain for Emergency Towing Arrangements

3 Terms and definitions

(1) Marine anchor cables and accessories: The products mentioned in Section 2, Chapter 10, Part 1 of the CCS Rules for material and welding.

(2) Mooring chain and accessories: The products mentioned in Section 3 Chapter 10, Part 1 of the CCS Rules for material and welding.

(3) Anchor chain cables and accessories: The general name for the marine anchor cables and mooring cables and accessories.

4 Plans and documents

4.1 A manufacturer intending for approval by CCS is to submit an application to CCS for works approval.

4.2 The documents as following are to be submitted to CCS for information.

(1) Particulars of the manufacturer ,including the name ,address, history ,production capacity, technical and inspection personnel, main products, subordinate relationship, trademark etc.;

(2) Details for the products for approval;

(3) Main production equipment;

(4) Main test equipment;

(5) The chemical composition rang of the products for approval;

(6) Brief production technology of the products for approval;

(7) Quality management documents;

(8) Document of entering to the register of enterprise;

(9) Qualification certificate and/or production license;

(10) Specimen of products quality certificate;

(11) Quality control scheme(where applicable);

(12) Qualified supplier list(where applicable);

4.3 Approval test program should be submitted to CCS for approving.

5 Technical requirement

5.1 Except for M1 grade, steel of all grades for anchor chain cables and accessories are to be manufactured only by works approved by CCS.

5.2 Each grade is to be individually approved. Approval for a higher grade does not constitute approval of a lower grade. If it is demonstrated to be satisfaction of CCS that the higher and lower grades are produced to the same manufacturing procedure using the same chemistry and heat

treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification are not to be modified during production.

5.3 The steel intended for anchor cables and accessories are to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. Steel of all grades intended for anchor cables and accessories are to be killed. Except for M1 grade steel, other steel of grades are to be fine grain treated. Grades MR4S , MR5 and MR6 intended for mooring chains and accessories are to be vacuum degassed.

5.4 The rolling reduction ratio of round steel intended for mooring chains and accessories is to be recorded and is to be at least 5:1. The rolling reduction ratio used in production can be higher, but should not be lower than that qualified.

5.5 Forgings intended for mooring chains and accessories are to have wrought microstructure and the minimum reduction ratio is to be 3 to 1. The forging reduction ratio, used in the qualification tests, from cast ingot/slab to forged component is to be recorded. The forging reduction ratio used in production can be higher, but should not be lower than qualified. The degree of upsetting during qualification is to be recorded and maintained during production. Heat cycling during forging and reheating is to be monitored by manufacturer and recorded in the forging documentation. The manufacturer is to have a maintenance procedure and schedule for dies and tooling which shall be submitted to CCS.

5.6 The steelmaker is to be submit a specification of chemical composition of steel intended for mooring chains and accessories approved, which must be approved by CCS and by the mooring chains and accessories manufacture. The steel maker is to conform by analysis and testing that the specification is met. For grade MR4, MR4S , MR5 and MR6 , the steel shall contain a minimum of 0.20 per cent molybdenum.

5.7 Forges and foundries intending to be approved is to be submitted a description of manufacturing processes and process controls of forgings and castings to CCS.

5.8 A heat treatment sensitivity study simulating mooring chains and accessories production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations. Cooling after tempering shall be appropriate to avoid temper embrittlement. All test details and results are to be submitted to CCS.

5.9 The steel manufacture is to provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for MR3S, MR4, MR4S , MR5 and MR6, hydrogen embrittlement. All test details and results are to be submitted to CCS.

5.10 All the products mentioned in this guideline ,its technical and performance requirements meets the requirements of CCS Rules for Classification of Sea-Going Steel Ships and CCS Rules for Materials and Welding and relative national and international standards.

5.11 Approval of quality system at steelmaker for anchor cables and accessories

Steelmaker intending to approve anchor cables and accessories is to have a documented and effective quality system approved by CCS. The provision of such a quality system is required in addition to , and not in lieu of , the witnessing of tests by a Surveyor.

6 Materials and parts

For steel mills where the materials are purchased, the materials suppliers are to be approved by CCS. The approval of materials is to refer to the requirements of this guideline.

7 Type test

7.1 Determination of the Type test program

Prior to type test, CCS and the applicant are to determine the type test program through negotiation. The program may be proposed by the applicant and examined and approved by CCS, or proposed by CCS and confirmed by the applicant. The program is to include:

7.1.1 The type, specification and delivery condition of the products for approval (indicating the deoxidation, chemical composition, grain refining elements, (simulating) heat treatment process and delivery condition for each steel grade);

7.1.2 Steel grade, specification, and heat treatment of the selected products for test;

7.1.3 The test items and the standards or rules adopted;

7.1.4 Sampling scheme and descriptions;

7.1.5 Place of test and qualification of the laboratory (if applicable, the qualification of the subcontractor and the agreement).

7.2 Selection of typical samples

The typical samples for type test are to be selected according to the following requirements:

7.2.1 The typical samples are to be taken for type test from the largest products for each grade individually. The products with the maximum specification are to be selected respectively for continuous casting and mould casting. Where electric furnace and converter are for smelting, the products with the maximum specification are to be selected accordingly. CCS may require additional approval test for the smallest or medium products as the case may be.

7.2.2 Depending on the resources of the manufacturer, the sampling process may be confirmed by tracking sampling or production process or by tracing relevant information through production control computer.

7.2.3 The materials (billets, ingots) for rolled steel bars for test are to be designated by the

Surveyor. The test samples are to be taken from the top and bottom of the bars.

7.3 Where the selected typical samples are adopted as the samples for approval, the manufacturer is also to provide the following information on the products:

(1) the steel making , continuous casting procedure and the material requirement including the chemical composition ,mechanical properties and non-destructive test requirement;

(2) Rolling procedure and the rolling reduction ratio;

(3) Forging process and forging reduction ratio;

(4) The heat treatment.

7.4 Type test items and requirements

7.4.1 The type test items and requirements are as follows:

(1) Chemical composition analysis: compositions of ladle sample and finished products to be analyzed respectively. The elements to be analyzed are C, Si, Mn, P, S, Cr, Ni, Mo, Cu, Als, Nb, V, Ti, N, H, O and other added ones (Als not required for M1).

(2) Tensile test: To determine the upper yield strength ReH, tensile strength Rm and elongation A, and the yield to tensile ratio to be calculated.

(3) Bend test

① Test specimens: For diameter not exceeding 40 mm, to be taken as a cylindrical bar with full cross-section or a cylindrical bar of 25 mm in diameter with one rolled surface; for diameter exceeding 40 mm, to be taken from the bars in longitudinal direction with center line at a position of 1/6 diameter from the surface or as close as possible to this position;

② Bending angle of 180°: d= a for M1, d=1.5a for M2 and M3; for diameter not less than 25 mm (uncut test specimens), d=2a for M1, d=2.5a for M2 and M3. (d is the bending center diameter， a is the diameter of the sample)

(4) Charpy V-notch impact test

① The test is to determine the energy with a set of three test specimens, and the individual

value and average value of energy to be provided. Impact test is not required for grade M1 steel.

② The temperature requirements for impact test: Normal temperature, 0℃ and -20℃ for M2, normal temperature, 0℃, -20℃ and -40℃ for M3, MR3 and MR3S, normal temperature, 0℃, -20℃, -40℃ and -60℃ for MR4, MR4S , MR5 and MR6.

③ The fracture photos and side expansion value are to be provided.

(5) Hardness test: Steels for each grade are to be subject to hardness test. Specimens may be prepared individually or apply residual samples (parts without deformation) of tensile and impact tests. Hardness of MR4S steel is not to be greater than 330HBW, and hardness of MR5 steel is not to be greater than 340HBW

(6) Sulphur prints: Sulphur prints to be taken with full cross-section (or 1/2) of the material; for bars, sulphur prints to be taken with a full cross-section or a longitudinal section through axis (length of specimen/diameter ≧1.2). The photos of sulphur prints are to be provided.

(7) Hydrogen embrittlement test of MR3S, MR4, MR4S, MR5 and MR6 grades steel: test requirements and methods and result assessment are to comply with CCS Rules for Materials and Welding.

(8) Macrostructure: The requirements for position and length of the specimen for the materials and finished products are the same as those for sulphur prints.

(9) Microstructure and grain size: Microstructure (×100 magnification) to be prepared in at a position of 1/6 diameter from the surface or as close as possible to this position to determine actual austenite grain size and non-metallic inclusions (or ×500 magnification as the case may be)and the metallography should be submitted..

(10) Welding property test: Rolled steel bars for anchor chain cables and mooring chain cables are to be subject to welding property test in an initial approval. The sampling material is to be welded by actual production technology of those chain cables, and the welds (after heat treatment) are to be subject to mechanical property tests (tensile, impact, hardness) and technological test (bend), in which, the hardness test is to determine the maximum hardness and hardness distribution in heat affected zones of welding.

(11) Visual and dimensional examination: Each product(bars, forgings and castings) is to be examination. The diameter, roundness, the curvature per meter and the total curvature are to be examined for each piece. The diameter tolerance and roundness tolerance are to

comply with the requirements of CCS Rules for Materials and Welding.

(12) Non-destructive test: Steel intended for typical samples of mooring chains and accessories is to be subjected to ultrasonic examination, magnetic particles, eddy current of an equivalent method at an appropriate stage of the manufacture. The non-destructive examination is to be performed in accordance with CCS Rules for material and welding and recognized standards. Non-destructive test procedures together with rejection/acceptance criteria are to be submitted to CCS for information.

(13) The following tests shall also be carried out on MR6 steel for mooring chain and accessories:

① Quenching degree test;

② Heat treatment sensitivity test. A heat treatment sensitivity study simulating chain or accessory production conditions shall be applied in order to check the candidate material's sensitivity to deviations from a target (optimum) heat treatment route. At least 9 test blocks with complete section shall be taken from the chain steel for heat treatment and mechanical property test. Heat treatment process conditions shall be carried out according to the requirements of Table 2;

Heat treatment process conditions **7.4.1(13)**

No.	Austenitisation		Tempering	
	Temperature [°C]	Time [minutes]	Temperature [°C]	Time [minutes]
1	Ac3 + 30	30	610	60
2	Ac3 + 60	30	610	60
3	Ac3 + 90	30	610	60
4	Ac3 + 60	60	610	60
5	Ac3 + 60	30	570	60
6	Ac3 + 60	30	590	60
7	Ac3 + 60	30	650	60
8	Ac3 + 60	30	610	30
9	Ac3 + 60	30	610	90

③ Mechanical testing, material intended for normalizing. For chain or accessories supplied in the normalised condition, at least one sample of full cross section shall be heat treated and subjected to tensile and Charpy V-notch testing. Impact test temperature shall be -20 ℃.

④ Temper embrittlement testing(Q+T condition), at least two samples of full cross section shall be heat treated and subjected to Charpy V-notch testing. Test temperatures shall be

0℃, -20℃ and -40℃. The impact property at -20℃ shall meet the requirements of section 12, Chapter 3, Part 1 of CCS Rules for Materials and Welding. The heat treatment process conditions for the samples:1) Austenitisation at Ac3 + 60℃ for 30 minutes. Tempering at 570℃ for 60 minutes. Rapid cooling in water.2) Austenitisation at Ac3 + 60℃ for 30 minutes. Tempering at 570℃ for 60 minutes. Slow cooling inside furnace for at least 40 minutes down to 300℃.

⑤ Strain age testing, at least one sample of full cross section taken from the anchor chain steel is heat treated. After heat treatment, the sample is subjected to 5% plastic deformation, and then heated to 100℃ and held for 1 h. The impact test is conducted at the temperature of 0℃, - 20℃ and - 40℃. The impact property at - 20℃ shall meet the requirements of section 12, Chapter 3, Part 1 of CCS Rules for Materials and Welding.

(14) Other test items as deemed necessary by CCS (ie thermal transformation curve for austenite, tower type test, etc.).

(15) After all the type test are carried out and are matched, the steel (MR3, MR3S, MR4, MR4S , MR5 and MR6) approved should be manufacture to the finish mooring chains and accessories, the relative type test for the mooring chains and accessories should be carried out and are got the satisfactory, the approval of the steel for the mooring chains and accessories could be issued.

7.4.2 For steel mills where the materials are purchased, the materials suppliers are to be approved by CCS and subject to sulphur prints/macrostructure examination, chemical composition analysis, visual and dimensional examination. Qualified materials are sent to mills to make steel bars and subject to test according to the 7.4.1 requirements. The materials suppliers may be approved after all satisfactory tests.

8 Unit/batch inspection

8.1 After works approval by CCS, the steel as manufactured according to the approved conditions (including equipment, process, etc.) are to be applied by the manufacturer for unit/batch inspection by CCS, which can be used only after satisfactory inspection.

8.2 The detailed requirements for unit/batch inspection after approval are to be notified in written form to the works when CCS issues a certificate of works approval.

8.3 The unit/batch inspection is to be carried out according to the approved test program. The test program is to contain the test items for witness, review and on-site examination. The items are at least to include:

(1) Visual and dimensional examination;

(2) Review of the result of chemical analysis;

(3) Mechanical property test;

(4) Austenitic grain size examination (for offshore mooring chain and accessories steel);

(5) Non-destructive test (for offshore mooring chain and accessories steel);

(6) Hydrogen embrittlement test (for MR3S, MR4, MR4S , MR5 and MR6 for offshore mooring chain and accessories steel);

(7) Macro acid corrosion examination (for MR4S , MR5 and MR6 for offshore mooring chains and accessories steel);

(8) Non-metallic inclusion examination (for MR4S , MR5 and MR6 for offshore mooring chains and accessories steel;

(9) Quenching degree test (for MR4S, MR5 and MR6 for offshore mooring chains and accessories steel);

(10) Other test items as deemed necessary by CCS.

8.4 After satisfactory inspection of products, CCS Surveyor is to issue a certificate of marine products or endorse the manufacturer’s quality certificate.

8.5 The quality certificate is to contain at least: acceptance criteria (rules, standard, technical agreements, etc.), cast number/batch number, steel grade, specification, wight, quantity, delivery condition, chemical composition, mechanical properties, description of identifications. For MR4S , MR5 and MR6 rolled steel bars for mooring chain cables, results of hydrogen embrittleness test and non-destructive test as well as results of austenitic micro grain size, non-metallic intrusions and hardenability test are also to be listed. The space for stamp and endorsement by CCS Surveyor is to be reserved.

8.6 The format of the manufacturer’s quality certificate is to be approved by CCS.