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W-01 ROLLED STEEL

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Foreword:

This Guide is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

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ROLLED STEEL

1 Application

1.1 This Chapter applies to the works approval and products inspection of the rolled steel, i.e. normal strength hull structural steel, high strength hull structural steel and high strength quenched and tempered steel for welded structure (including plates, strips and sections) and its materials (including billet, slab and ingot), which are manufactured according to the requirements of CCS Rules for Classification of Sea-going Steel Ships and CCS Rules for Materials and Welding.

1.2 Where steels are intended for use in boilers and pressure vessels, reference may be made to in this Chapter. Additional property tests may be necessary for works approval and products inspection subject to agreement by CCS.

1.3 For a rolled coil steel plating works, where the unreeling and crosscutting need subcontracted, the quality management and quality control of the subcontractor on dimension, appearance, straightness and marks transfer are to be included in the works approval by CCS.

1.4 The rolled coil steel unreeling works is to be subject to works approval by CCS and to type test as appropriate. The unreeled steel plates are to be subject to inspection and a quality certificate endorsed by CCS Surveyor after satisfactory inspection.

1.5 For a rolled steel plating works, where the billet steel need to be purchased, the billet material is to be ordered from the billet works as approved by CCS.

2 Normative references

The basis for approval and inspection of rolled steel works to which this Chapter apply are as follows:

- (1) CCS Rules for Classification of Sea-going Steel Ships;
- (2) CCS Rules for Materials and Welding;
- (3) IACS UR W11 Normal and Higher Strength Hull Structural Steels;
- (4) IACS UR W16 High Strength Quenched and Tempered Steel for Welded Structures;
- (5) relevant national and international standards.

3 Plans and documents

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

3.2 The applicant is to submit the following documents in triplicate to CCS for information.

3.2.1 Particulars of the manufacturer:

the name, address and history of the manufacture; the type and specification of the manufactured products; the type, specification and delivery condition of the products for approval; the chemical composition and mechanical properties of the steel grades or similar steel type, specification, delivery condition of the products for approval (to prove the high quality and stability); other recognized qualification certificates.

3.2.2 Management documents, including quality system documents:

- (1) organizational structure, quality control points, responsibilities of management departments / managers, quality management system documents, identification and documentary trail or related descriptions;
- (2) for a rolled steel plating works, where the billet steel need to be purchased, the provisions for control of such purchase and acceptance are to be established.

3.2.3 Main production, inspection/test equipment:

- (1) information on main production equipment: parameters of blast furnace and steel-making furnace, casting equipment, types/relevant parameters of heating furnace, parameters of the rolling mill (the power of main motor, maximum rolling force, size of roll, main control means of the rolling mill such as hydraulic AGC), parameters of on-line accelerating cooling system, types/parameters of heat treatment furnace, shearing equipment, straightening equipment, cooling bed, falten steel coil equipment.
- (2) main inspection/test equipment: equipment for chemical composition analysis, mechanical property test and NDT. The manufacturer itself is to be equipped with the above inspection/test equipment.

3.2.4 Process documents

Flow chart of manufacturing process, component design of approved steel type, control criteria of the manufacturer, technological specifications (operation guidance) in which the following are to be included:

(1) hot metal pretreatment and steelmaking:

- pre-desulphurization method of hot metal;
- deoxidation method, grain refining elements;
- information on materials and quality control;
- refining means (LF, RH, VD);

(2) casting:

- casting method;
- size and mass of ingots, size of continuous cast billets;
- quality control measures (electromagnetic stirring, soft reduction, etc.);

(3) rolling:

- heating system;
- descaling, water pressure;
- measurement of temperature and thickness;
- initial and finishing rolling temperatures (and total reduction for supply in the controlled rolled condition or TMCP);
- on-line cooling method, cooling parameters;

(4) heat treatment:

- heat treatment system;

(5) for hot rolled steel plate, the following are to additionally be submitted:

- specification and mass of the maximum and minimum coils;
- reeling temperature;
- information on unreeling, straightening, crosscutting, sampling and marking.

3.2.5 Qualification certificate of the test and inspection personnel.

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

3.4 Other documents where deemed necessary by CCS.

4 Type test

4.1 Determination of the type test program

Prior to works approval, 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:

- (1) the type, specification and delivery condition of the products for approval (the clear relationship between deoxidation method, grain refining elements and delivery condition for different grades);
- (2) the steel grade, specification, number and delivery condition of the typical samples for test approval;
- (3) the test items and the standard or rules adopted;
- (4) sampling position, schemes and sampling instructions;
- (5) place of test and qualification of the laboratory (if applicable, the qualification of the subcontractor and the agreement);
- (6) name of the test organization.

4.2 Selection of typical samples for type test

The requirements are as follows:

- (1) The typical samples are to be taken for type test from the largest products for each type and each delivery condition. CCS may require additional approval test for the smallest or medium products as the case may be.
- (2) For materials with similar composition design and the same manufacturing method and delivery condition, subject to consent of CCS, higher roughness grade may cover lower roughness grade for the same strength (such as B cover for A),.The yield strength equal or less than 390 N/mm^2 , the higher strength grade can cover lower strength grade within two

grade, while yield strength more than 390 N/mm² the higher strength grade can cover lower strength grade just within one grade.

- (3) The test plates are to be rolled at the positions corresponding to the top and bottom of billets (top of ingots), and the test specimens are to be taken at the top or bottom of the plates. CCS may randomly designate casting blank to rolled steel plate for type test as deemed necessary.
- (4) For coils, test specimens are to be taken from the top, middle and bottom respectively, see for the test items in 1.4.3. In approval of an unreeling works, the test specimens are to be taken from the top, middle and bottom for tensile, impact and ageing impact testing. The steel coil manufactures should specify the distance cut from the top and tail of the steel coil, and inform the CCS and the coil flattening and machining works.
- (5) In application for materials approval, the materials are to be rolled into finished products for mechanical property test.

4.3 Type test items and requirements

Type test items and requirements are given in Table 4.3 with details as follows.

4.3.1 Chemical composition analysis

The inspection requirements are given in Table 4.3. Elements Sb and B are to additionally be determined where electric arc furnace is applied.

4.3.2 Tensile test

- (1) Tensile specimens are to be of full thickness. For plates over 40 mm thick, round test specimens may be used with sampling location at 1/4 and 1/2 of the thickness of the product.
- (2) Tensile specimens are to be taken longitudinally and transversely respectively. For strips and sections of less than 600 mm in width, the specimens may be taken only longitudinally.
- (3) For materials showing no yield phenomenon, the proof strength $R_{p0.2}$ is to be determined.
- (4) Where the steel is supplied in TMCP condition, the tensile test of stress relief is to be conducted with heating temperature of 600°C and heating time of 2 min/mm, but not less than one hour.

4.3.3 Bend test

The bend test specimens are to be 30 mm in width (while the thickness is less than 6mm, $b=5a$, a for steel thickness) and bent to an angle of 180° with the diameter of bend mandrel referred to relative national standard.

Note: For the minimum specified tensile strength equal or less than 460Mpa the bend test should be carried out, with the diameter of the bend mandrel referred to the GB/T700、GB/T1591.

4.3.4 Charpy V-notch impact test

- (1) Charpy V-notch impact test is to determine the energy, the percentage of crystalline fracture and side expansion value, and a curve is to be drawn to determine the brittle transition temperature (normally corresponding to 50% crystalline fracture). The photo of the fracture is to be provided.
- (2) The temperature requirements for impact test are given in Table 4.3.
- (3) For materials of thickness less than or equal to 40 mm, the impact specimens are to be taken close to the surface; for materials of thickness more than 40mm, the specimens are to be taken at $1/4$ and $1/2$ of the thickness respectively.
- (4) Plates of less than 6 mm in thickness may be free from impact test.
- (5) Sections of less than 600 mm in width may be tested only in longitudinal direction.
- (6) For steel bars of less than 60 mm in diameter, the specimens are to be taken at $1/3$ of the radius from the outer surface. Where the diameter is more than or equal to 60 mm, the specimens are also to be taken at the core.

4.3.5 Ageing impact test

The temperature requirements for ageing impact test are given in Table 4.3.

4.3.6 Sulphur print test

- (1) The test is to be carried out on the materials having the maximum thickness. For plates, the sulphur prints are to be taken for half cross section from the center to the side of the plate. For slabs, the sulphur prints are to be taken for full cross section.

- (2) The sulphur prints for plates are to be taken from the middle of the plate with length greater than 600 mm.

4.3.7 Macrostructure examination

The macrostructure examination is to be carried out on materials and finished products. The requirements for sampling position and length are the same as those for sulphur prints.

4.3.8 Metallographic examination

The metallographic examination ($\times 100$ and 500 magnification) is to be carried out close to the surface and at the mid-wall thickness respectively to measure actual grain size. Where the thickness of the product is over 40 mm, additional samples are to be taken at $1/4$ thickness.

4.3.9 Drop weight test

- (1) For the first approval or additional items approval of the plates with steel types other than A, B, AH32/36, the plates with maximum thickness and highest grade of steels are to be selected for drop weight test. Transverse specimens are to be taken.
- (2) The standard for the test is ASTM E208 (GB/T 6803).

4.3.10 Mechanical test in through-thickness

For plates with mechanical properties of Z-Direction, a tensile test in through-thickness is to be conducted to determine the reduction of area Z.

4.3.11 Non-destructive test

- Z-direction steels are to be subject to ultrasonic examination.,the method and the result should meet the requirement of the <Rules for material and welding>.

4.3.12 Property test at elevated temperature

For steels requiring elevated temperatures such as boiler steel, a tensile test at elevated temperatures is to be carried out. The test temperatures are 50°C , 100°C , 150°C , 200°C , 250°C , 300°C , 350°C , 400°C and 450°C .

4.3.13 Welding property test

- (1) For the first approval and additional items approval of plates from grade E of normal strength hull structural steel, high strength hull structural steel or quenched and tempered steel, the plates with maximum thickness and highest grade are to be selected for welding property test.
- (2) A butt specimen is to be welded with heat input about 15 kJ/cm and 50 kJ/cm respectively. The weld is to be perpendicular to the direction of rolling.

For steels requiring high heat input, in addition to less than 50 kJ/cm, the maximum heat input in accordance with the products standard is to be adopted to butt-joint specimens with X or K. The usual welding procedures are to be adopted as much as possible. The weld is to be perpendicular to the direction of rolling. All the welding parameters, such as consumables designation code and diameter, edge preparation, preheating temperature, interposes temperature, current, amperage, voltage, travel speed, heat input value and passes, are to be submitted.

- (3) The specimens are to be subject to the following tests:

- ① two full-thickness specimens (transverse) for tensile test. When the breaking strength of a test specimen exceeds the capacity of the test machine, the test specimen may be divided into several portions and the thickness of each specimen is not to be less than 25 mm. The average value of the tensile results obtained from the several specimens may be taken as the result of the full thickness butt weld joint. The specimens are to be machined flush with the surface of the plate. The tensile strength value and position of fractures of the specimens are to be submitted;
- ② a weld face bend specimen and a weld root bend specimen. The breadth of specimens is 30 mm and the diameter of the bend mandrel : $d=4a$ ($\text{ReH} \leq 400 \text{ N / mm}^2$); $d=5a$ ($400 \text{ N / mm}^2 < \text{ReH} \leq 500 \text{ N / mm}^2$) ; $d=6a$ ($500 \text{ N / mm}^2 < \text{ReH} \leq 690 \text{ N / mm}^2$) where a is the thickness of the specimen, the bending angle α equals 180° . Where the thickness of the plate is more than 20 mm, two side bend specimens may be prepared;
- ③ a set of three impact test specimens perpendicular to the weld. The notches of specimens are to be located at the center of weld, on the fusion line and at 2 mm, 5 mm and 20 mm from fusion line. The fusion line is to be determined by corrosion test. The temperature for impact test is taken as the temperature of the approved plates in delivery condition. The sampling position is 1 to 2 mm from the surface of the plates. Where the thickness is more than 50 mm, additional specimens are to be taken from the root of the weld of the X or K edge, and the notches of specimens are located as same to the above;

- ④ HV10 hardness distribution test: hardness distribution test is to be carried out on the cross section of the weld 1mm from the upper and lower surfaces of the plates respectively. The measuring points are on the weld, the fusion line, at the heat affected zones and on the parent metal. The space between the measuring points is about 0.7 mm, and the heat affected zone of each side is to have at least 3 to 7 measuring points.

The maximum hardness value usually is not to be greater than HV350, for the minimum specified tensile strength equal or less than 420 N/mm^2 , and the maximum hardness value usually is not to be greater than HV420 for the minimum specified tensile strength more than 420 N/mm^2 . ⑤ The photos of edge preparation, dimension, passes, hardness value and joints are to be submitted to CCS;

- ⑥ steels requiring high heat input are to be subject to macrostructure and microstructure test. The sectional surface of the welds is to be free from such defects as cracks and lack of fusion. A micro-specimen is to be taken from the weld, fusion line, and 2 mm, 5 mm, 10 mm, 20 mm from the fusion line respectively along the centerline of the through-thickness;

- ⑦ non-destructive test for the specimens.

4.3.14 Dimensional and visual examination

- (1) For the type test all the plates rolled by the test billet the dimensional and visual examination should be carried out. The length, width, thickness and irregularities of each plate are to be measured. Thickness measurement methods and requirements are to comply with relevant requirements of 2011 Amendments to CCS Rules for Materials and Welding. Other measurement values are to be in compliance with the specific requirements of GB/T709.
- (2) For rolled coil, a coil is to be selected to measure the thickness, width and tower. The values are to be in compliance with the specific requirements of GB/T709.
- (3) For steel plate processed from steel coil, select at least 5 pieces in one coil by random are carried out the dimension test, each piece should inspecte the length, width, thickness and flatness, the result should meet the requirement of GB709.
- (4) For sections in the type test all the section should be inspected in dimension and the values are to be in compliance with the relevant standards.

(5) The external quality is to be in compliance with the relevant standards.

4.3.15 Dimensional and visual examination are to be increased for the approval of steel materials.

4.3.16 CTOD test.: for the initial approval or change of approval E,EH32/36/40, FH32/26/40, E420~690, F420-690 etc .the CTOD should be carried out,for determining the material fracture roughness. The sampling ,making the test sample, test method should meet with Section 8,Chapter 2 of CCS<Rules for material and welding>and other equivalent standard.

4.3.17 Other test items where deemed necessary by CCS.

4.3.18 In general, the preparation of samples and mark transfer are to be in the presence of the Surveyor.

4.3.19 Test items other than those for chemical analysis, tensile, impact, ageing impact and metallographic examination may be dispensed with subject to approval by CCS.

4.3.20 The manufacture have the steelmaking,continuous-casting and rolling capacity ,and billet for the the rolled products is manufactured by self ,the relative billet work approval certificate can be issued meanwhile the rolled product work approval certificate is issued.

5 Unit/batch inspection

5.1 The unit/batch inspection of rolled steels is to be carried out after works approval according to CCS Rules for Classification of Sea-going Steel Ships.

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

5.3 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 witnessor review. The items include the mechanical test (tensile test, impact test, etc.), and non-destructive test (if required) r; chemical analysis; examination of external appearance and dimension. If necessary, the Surveyor may check the technical or test record, or propose additional test times.

5.4 The unit/batch inspection for steel plate processed from steel coil

The surveyor should check the steel coil certificate and random check the process of uncoiling , dimension ,appearance and transfer the stamp., The check rate should no less than 10%.

If the surveyor have any suspect on the manufacture quality certificate ,the chemical reinspection or the mechanical property test with sample taken from the top or tail should be carried out.

When the manufacture flating the coil from the new steel coil supplier for the first time, the mechanical property test(tensile test and impact test).should be carried out and the samples taken from the top,middle and tail in one coil which selected by random. The results of the mechanical property test should not less than former's obviously.

5.5 The steel coil thickness should be integer multiple of 0.5mm .

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

- (1) The quality certificate is to at least contain: acceptance criteria (rules, standard, technical agreements, etc.), cast number/batch number, steel grade, specification, mass, number, delivery condition, chemical composition (and carbon equivalent for higher strength hull structural steel), mechanical properties, description of identification, ship's name/project number/contract number (if any). The space for stamp and endorsement by CCS Surveyor is to be reserved.
- (2) The quality certificate of steel coil should be noted:This steel coils in this certificate cannot be used on board as the hull structural steel directly until they are flatten and machined to steel plates with CCS surveyor inspection and certificate issued by CCS for steel plate is required.
- (3) The steel plate processed from steel coil should have the CCS certificates or the certificate issued by CCS base on the manufacture quality certificate. The chemical component ,mechanical property ,thickness and specification should be original from the steel coil certificate and it should be noted"the data original from the steel coil certificate". The original copy of steel coil should be submit to CCS.
- (4) The quality certificate of the the steel plate processed from steel coil should maintain the information of the manufacture name, grade,specification ,weight, serial No.(cast No./Coil No.)and steel coil certificate No. from original steel coil cetificate.
- (5) The format of the manufacturer's quality certificate is to be approved by CCS.

Test items for type approval

Table 4.3

Test items	Applicable grades	Sampling requirements	Test requirements				Remarks
Chemical composition	A, B, D,E	ladle samples and finished products	C, Si, Mn, P, S, Cr, Ni, Mo, V, Cu, Al and other added elements				
	AH32/36/40, DH32/36/40, EH32/36/40, FH32/36/40		C, Si, Mn, P, S, Nb, V, Ti, Cr, Ni, Mo, Cu, Al, B, As, Sn, Pb, [N], [H], [O] and other added elements				
	A420~690, D420~690, E420~690, F420~690,						
Tensile test	all grades	top and bottom longitudinal and transverse	ReH, Rm, A				
Bend test	All grade	top and bottom	longitudinal and transverse				
Impact test			temperature °C				
	A, B, AH32/36/40, A420~690	top and bottom longitudinal and transverse	+20	0	-20	-40	
	D, DH32/36/40, D420~690		0	-20	-40	-60	
	E, EH32/36/40, E420~690		0	-20	-40	-60	
	FH32/36/40, F420~690		-20	-40	-60	-80	
Ageing impact test	A, B, AH32/36/40, A420~690	top and bottom longitudinal	+20	0	-20		5% plastic deformation, ageing for one hour at 250°C, not lower than the required value of assessment temperature
	D, DH32/36/40, D420~690		0	-20	-40		
	E, EH32/36/40, E420~690		-20	-40	-60		
	FH32/36/40, F420~690		-40	-60	-80		
Sulphur prints	the same as sampling requirements	materials and finished products					
Macrostructure	the same as sampling requirements	one end					

Continued table 4.3

Test items	Applicable grades	Sampling requirements	Test requirements	Remarks
Drop weight	grades other than A, B, AH32/36	transverse	Test temperature is selected according to GB/T 6803	
Z-direction tensile test	Z-direction steel	top and bottom	refer 4.3.10	
Non-destructive test	Z-direction steel	all	refer 4.3.11	
Property test at elevated temperature	Steel for boiler(if the elevated temperature mechanical is required)	top and bottom	refer 4.3.12	
Welding property	E, higher strength steels and quenched and tempered steels	refer 4.3.13	refer 4.3.13	
Dimension and appearance	all	refer4.3.14	refer 4.3.14	
Base material CTOD test	E, EH32/36/40, FH32/36/40, E420~690, F420~690	refer Rules for Materials and Welding	Specimen of full thickness, see Rules for Materials and Welding	The feature value is based on 0.25mm and the result is for reference