Guideline No.:W-05(202204)

W-05

STEEL FROGINGS

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Foreword

China Classification Society (hereinafter referred to as 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.

~~The product inspection guidelines of China Classification Society (hereinafter referred to as "CCS") specify the applicable technical requirements and inspection and test requirements of ship classification products and authorized statutory products to be approved / inspected by CCS.CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.~~

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

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

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Main changes:

~~1、Converted the relevant requirements about NDT in (2013）Circ.No.165 Total No.451 CCS Non-destructive Testing Acceptance Criteria and （2007）Circ.No.003 Total No.16 Notice about~~

1. Revise the structure of the guide, add "terms and definitions" and " Materials and components ", and adjust the relevant contents and full text format.

2. The requirement of "smelting method" in Article 4.1 (2) is added, and the relevant expression of "connecting rod journal" is deleted;

3. Article 7.4.5, test requirements for ring forged steel parts (for slewing ring) is added

4. The requirements of "dual phase steel" and "pitting test" in article 7.4.7 (7) are added

5. Article 7.4.7 (9) is added: "for austenitic stainless steel forgings used at - 100 ℃ and below, Charpy V-notch impact test at - 196 ℃ shall be carried out."

Contents

STEEL FORGINGS

1 Application

1.1 This Chapter applies to steel forgings intended for use in the hull structure, machinery, pressure vessels and piping systems, 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. Where it is proposed to use carbon or carbon-manganese steels or alloy steels other than those specified in CCS Rules, details of the chemical composition, mechanical properties and heat treatment process are to be submitted to CCS for approval, and such steels, subject to consent of CCS, may be accepted in accordance with the relevant standards recognized by CCS.

1.2 This Chapter also applies to rolled slabs and billets in stead of steel forgings, and applies to rolled round used for the manufacture (by machining operations only) of shafts, bolts, studs and other components of similar shape.

1.3 Forgings are to be made at a manufacturer approved by CCS. The steel used to forging is to be made at a steel works approved by CCS.

2 Normative references

2.1 CCS Rules for Classification of Sea-going Steel Ships;

2.2 CCS Rules for Materials and Welding;

2.3 relevant national and international standards.

3Terms and definitions

Nil.

~~3 Design and technical requirements~~

~~3.1 The methods of tensile, impact and cold bend tests are to comply with the relevant requirements in Chapter 2, PART ONEof CCS Rules for Materials and Welding.~~

~~3.2 Macrostructure, sulphur print and microstructure are to comply with the relevant recognized standards.~~

~~3.3. The ultrasonic testing should be met IACS Rec. No.68 or CB/T3907, magnetic particle ordye~~

~~penetration testing should be met IACS Rec. No.68.~~

~~3.4 The methods of chemical composition analysis and tolerance are to comply with the relevant recognized standards.~~

4 Plans and documents

4.1 A manufacturer intending for works approval by CCS is to submit the following documents to CCS for examination:.

(1)Basics information for manufacturer

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

② brief production technology of the products for approval;

③ quality management documents;

④ document of entering to the register of enterprise;

⑤ qualification certificate and/or production license;

⑥ specimen of products quality certificate;

⑦ quality control scheme (where applicable)

(2) Details of the products for approval:

grade and use of forgings (such as those for hull structure, shafts, machinery, pressure vessels and piping systems), type of steel (such as carbon or carbon-manganese steels or low alloy steels), mass and dimension of the maximum forging for approval, smelting method, forging method (such as open die, closed die, continuous grain flow), type of materials (such as ingot, billet), heat treatment method (such as normalizing, normalizing and tempering, quenching and tempering), and surface condition of delivery. The maximum mass and relevant dimension of the forging is interpreted as follows:

For open die forgings, they are grouped into shaft type, pie/disc type and ring type, among which maximum mass and diameter is to be taken for shaft type and height/thickness and

diameter is to be taken for pie/disc and ring types.

For closed die forgings, maximum projected area is to be taken.

For continuous grain flow forgings, diameter of connecting rod neck and mass of connecting rod are to be taken.

(3) A list of main production equipment, including the relevant parameters of the following equipment:

① capacity of secondary refining and vacuum treatment equipment (if applicable);

② the ultimate capacity of forging equipment;

③ the types of heating furnace and heat treatment furnace (capacity, fuel types, temperature control, arrangement of measurement points, cooling equipment adopted for heat treatment);

④ surface hardening method of forgings and equipment (if applicable);

⑤ lifting appliances.

(4) A list of inspection/test equipment, includingthe relevant parameters of the following equipment:

① the methods of chemical composition analysis (such as chemical analysis, spectral analysis) and elements to be analyzed;

② mechanical properties (including hardness);

③ non-destructive test equipment;

④ metallographic examination (if required);

⑤a unit carrying out statutory survey for the above equipment and the validity of appraisal.

(5) Qualification certificate of the test and inspection personnel.

(6) A flow card indicating each stage of the main technological process and the process for typical samples submitted.

(7) Cast number and batch number, identification mark of forgings,and documentary trail or related descriptions.

(8) The provisions for control of purchase or related descriptions:

① for a forging manufacturer, where the billet steel need to be purchased,the billet material is to be ordered from the billet works as approved by CCS, i.e. the materials for forgings are to be made in a works approved by CCS;

②During works approval, the forging manufacturer is to provide a list of material works with satisfactory results of assessment to CCS for information. Any change of list is to be subject to CCS agreement. Ingots/materials purchased by the forging manufacturer are to be the approved ones by CCS, and at least one chemical composition re-testis to be carried out per cast after delivery.

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

5 Technical requirements

5.1 The methods of tensile, impact and cold bend tests are to comply with the relevant requirements in Chapter 2, PART ONEof CCS Rules for Materials and Welding.

5.2 Macrostructure, sulphur print and microstructure are to comply with the relevant recognized standards.

5.3. The ultrasonic testing should be met IACS Rec. No.68 or CB/T3907, magnetic particle ordye penetration testing should be met IACS Rec. No.68.

5.4 The methods of chemical composition analysis and tolerance are to comply with the relevant recognized standards.

6Materials and components

The blank used for forging manufacturing shall be manufactured by the factory approved by CCS.

~~5~~ 7 Type test

~~5~~7.1 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 proposedby the applicant and examined and approved by CCS, or proposedby CCS and confirmed by the applicant. The program is to include:

(1) grade and use of forgings (such as those for hull structure, shafts, machinery, pressure vessels and piping systems), type of steel (such as carbon or carbon-manganese steels or low alloy steels), mass and dimension of the maximum forging for approval, forging method (such as open die, closed die, continuous grain flow),

(2) thename, drawing number, grade/designation, mass and dimension of the typical samples for test approval;

(3) thetest items and the standard or rules adopted, and the methods.

~~5~~7.2 Selection of typical samples

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

(1) Typical forgings are to be selected for different forging methods respectively (such as open die, closed die, continuous grain flow).

(2) According to each type of forgings (for hull structure, shafts or gears), theselected sample is to be capable of representing and covering the types of product for approval.

(3) In an initial approval, at least one piece of typical forging is to be selected, capable of representing the maximum forging capacityof the manufacturer in rough conditionwith more than 80% of themaximum material mass or maximum dimension. Where CCS deems necessary, an additional piece of forging may be taken for relevant test or inspection.

(4) Typical samples may be selected taking purchase order into consideration. For marine forgings, prior approval of the design drawing and technical conditions isto be obtained from CCS. For forgings not for marine use, the technical conditions are in general to comply with the requirements of CCS Rules for such forgings.

~~5~~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) theforging product drawing (including sampling position) and the technical requirements for materials, including the requirements for chemical composition, mechanical properties and non-destructive tests;

(2) forging process and forge ratio;

(3) heat treatment process.

~~5~~7.4 Type test items and requirements

~~5~~7.4.1 Chemical analysis of carbon or carbon-manganese steels or alloy steels is to contain the chemical compositions specified in CCS Rules for Materials and Welding for relevant forgings, and the elements stipulated in technical standards and conditions and patent for alloy steels.

~~5~~7.4.2 The number of specimens for tensile, impact, hardness and cold bend tests (if applicable)is to depend on the mass and dimension of each forging.

(1) The detailed requirements for sampling of different types of forgings are referred to in CCS Rules for Materials and Welding.

(2) Mechanical property test is to be carried out in accordance with the relevant requirementsof CCS Rules for Materials and Welding. In case of lack of such provisions, other recognized standards may be adopted.

~~5~~7.4.3 The specimen for hardness test may be taken from tensile specimens or impact specimens (from the intact part).

~~5~~7.4.4 Ultrasonic test and visual examination of the products.

7.4.5 For ring forged steel parts (for slewing ring), CTOD test and fatigue test shall be carried out (refer to GB / t4337 metal rotating bending fatigue test method for requirements).

~~5~~7.4.~~5~~6 Special requirement of alloy steel used for intermediate shaft material

For the alloy steel which has a minimum specified tensilestrength greater than 800 N/mm2, but less than 950 N/mm2 intended for use as intermediateshaft material:

(1) The test is to be carried out with notched and unnotched specimens respectively. For calculation of the stress concentration factor of the notched specimen, fatigue strength reduction factor β should be evaluated in consideration of the severest torsional stress concentration in the design criteria.

① Test conditions in accordance with Table 7.4.6(1):

Table 7.4.6(1)

Loading type	Torsion
Stress ratio	R=-1
Load waveform	Constant-amplitude sinusoidal
Evaluation	S-N curve
Number of cycles for test termination	1 x 10^7 cycles

②Acceptance criteria

Measured high-cycle torsional fatigue strength and low-cycle torsional fatigue strength are to be equal to or greater than the values given by the following formulae:

$$\tau_{c1} \geqq \tau_{c,\ \lambda=0} = \frac{\sigma_B + 160}{6} \times C_K C_D$$

$$\tau_{c2} \geqq 1.7 \times \frac{1}{\sqrt{C_K}} \tau_{c1}$$

$$C_K = \frac{1.45}{scf} \quad k = \left[\frac{scf}{1.45}\right]^x$$

$$scf = \alpha_{t\ (hole)} + 0.8 \times \frac{(1-e)/d}{\sqrt{\left(1-\frac{di}{d}\right) \times \frac{e}{d}}}$$

$$\alpha_{t\ (hole)} = 2.3\text{-}3 \times \frac{e}{d} + 15 \left(\frac{e}{d}\right)^2 + 10 \left(\frac{e}{d}\right)^2 \left(\frac{di}{d}\right)^2$$

~~$\tau_{c1} \geqq \tau_{c,\ \lambda=0} = \frac{\sigma_B + 160}{6} \cdot C_K \cdot C_D$~~

~~$\tau_{c2} \geqq 1.7 \cdot \frac{1}{\sqrt{C_K}} \tau_{c1}$~~

~~$C_K = \frac{1.45}{scf} \quad k = \left[\frac{scf}{1.45}\right]^x$~~

~~$scf = \alpha_{t\ (hole)} + 0.8 \cdot \frac{(1-e)/d}{\sqrt{\left(1-\frac{di}{d}\right) \cdot \frac{e}{d}}}$~~

~~$\alpha_{t\ (hole)} = 2.3\text{-}3 \cdot \frac{e}{d} + 15 \cdot \left(\frac{e}{d}\right)^2 + 10 \cdot \left(\frac{e}{d}\right)^2 \cdot \left(\frac{di}{d}\right)^2$~~

where

——CK (for high cycle fatigue) factor for the particular shaft design features

——scf stress concentration factor, see M68.7.3 (For unnotched specimen, 1.0.)

——CD = $0.35+0.93d_o^{-0.2}$ size factor, do =shaft outside diameter, ——see M68.5

—— σ_B —= specified minimum tensile strength in N/mm2 of the shaft material

$\alpha_{t(hole)}$ represents the stress concentration of radial holes in this context e = hole diameter, ——d-=minimum required diameter, ——di =——actual diameter in mm of shaft bore, ——simplified to— $\alpha_{t(hole)}=2.3$ $\alpha_{t(hole)}=2.3$

(2) Cleanliness requirements: The steels（A、B、C、D、DS） are generally to comply with the minimum requirements of China Classification Society Rules for Materials and Welding.

57.4.67 Where the Surveyor deems necessary, the following items are to be subject to test:

(1) For large and major forgings, macrostructure, sulphur prints and metallographic (intrusions and grain size) examinations are to be conducted. The location of the test specimens is generally in the riser end.

(2) For forgings delivered in finished condition, dye penetration or magnetic particle examination is to be carried out to examine the defects on the surface or close to the surface.

(3) Where solid forged crankshafts are made by closed die or continuous grain flow, full details of the proposed forging method are to be submitted to CCS for approval. When necessary, the manufacturer is required to carry out tests to demonstrate that a satisfactory structure and grain flow are obtained.

(4) Where forgings are surface treated and chemical heat treated, in addition to surface hardness, the distribution and depth of the hardened zone are to be determined. Property test of the main body of forgings is to be carried out.

(5) Where the forgings are subject to a working temperature equal to or more than 350℃, mechanical properties at elevated temperatures are to be determined.

(6) Where hollow forgings for boilers, pressure vessels and piping systems are supplied in finished condition, pressure tests are to be carried out.

(7) ~~Austenitic stainless steel forgings are to be subject to intercrystalline corrosion test.~~Intergranular corrosion test shall be carried out for austenitic stainless steel and duplex steel forgings. The specific test shall be carried out in accordance with the relevant requirements of CCS rules for materials and welding.

(8) Forgings for marine diesel engines manufactured by patent technology are to be subject to tests stipulated in the patent technology approved by CCS.

（9）For austenitic stainless steel forgings used at - 100 ℃ and below, Charpy V-notch impact test at - 196 ℃ shall be carried out.

~~6~~ 8 Unit/batch inspection

~~6~~8.1 According to CCS requirements for lists of certified products, forgings required to be certified by CCS are to be applied for inspection by CCS, which can be used onboard ships only after satisfactory inspection. For major forgings such as marine shaft and rudder system and diesel engine components and parts, the drawings approved by CCS are to be submitted.

~~6~~8.2 The main procedure of unit/batch inspection: (1) review of forging and heat treatment process (for major forgings); (2) taking specimens; (3) test; (4) visual examination and non-destructive test; (5) report and information review.

Depending on different production stages and surface delivery condition, the test items are given in Table 6.2.1.

Tests for forgings Table 6.2.1

Delivery condition	Test items
Material	Chemical analysis of ladle sample or materials composition re-test
	Taking mechanical test specimens and following up②
	Mechanical test①(test items are in accordance with CCS Rules)
	Visual examination①
Rough machining	Ultrasonic detection②
	Visual examination①
Finishing	Magnetic particle/dye penetration test②
	Check of accuracy of dimensions①

Note: ①items to be witnessed by the Surveyor

②UT according to CB/T 3907 Ⅱ or IACS Rec. No.68, MT/PT according to IACS Rec. No.68, Items tested in the presence of the Surveyor unless otherwise agreed by the Surveyor..

For small major forgings to be tested in batch (pressure vessels, connecting rods, crankshafts, tie bolts), each of such forgings may be required for hardness test where deemed necessary by the Surveyor. The difference in hardness is in accordance with the corresponding tensile strengthgiven in Table 6.2.2.

Difference in hardness **Table 6.2.2**

Minimum tensile strength Rm (N/mm^2)	**Difference in Brinell hardness**
Rm<600	25
600≦Rm<900	35
Rm≧900	42

~~6~~8.3 Each forging after satisfactory inspection is to be marked with CCS stamp.

~~6~~8.4 The manufacturer should be Submit a certificate of quality for each or batch qualified steel forging(s), it contain at least::

(1) name of the purchaser and order number;

(2) name, drawing number, steel grade(model), surface condition of delivery;

(3) cast number/batch number, melting analysis chemical composition;

(4) details of heat treatment, including temperature and holding times;

(5) results of mechanical tests;

(6) results of macrostructure examination (if applicable);

(7) forgingratio;

(8) test pressure (if applicable);

(9) method and results of non-destructive examination(if carrying out).