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Low Alloy Steel Castings for General Engineering and Structural Purposes

一般工程与结构用低合金钢铸件

(ISO 9477:2023, High strength cast steels for general engineering and structural purposes, MOD)

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Low Alloy Steel Castings for General Engineering and Structural Purposes

1 Scope

This document specifies the manufacturing, technical requirements, test methods, inspection rules, marking and quality certificate of low alloy steel castings for general engineering and structural purposes, as well as casting protection, packaging, transportation and storage, etc.

This document is applicable to the production, inspection and delivery acceptance of low alloy steel castings for general engineering and structural purposes.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 222 Permissible Tolerances for Chemical Composition of Steel Products

GB/T 223.3 Methods for Chemical Analysis of Iron, Steel and Alloy - The Diantipyryl Methane Phosphomolybdate Gravimetric Method for the Determination of Phosphorus Content

GB/T 223.4 Alloyed Steel - Determination of Manganese Content - Potentiometric or Visual Titration Method

GB/T 223.60 Methods for Chemical Analysis of Iron, Steel and Alloy - The Perchloric Acid Dehydration Gravimetric Method for the Determination of Silicon Content

GB/T 223.68 Methods for Chemical Analysis of Iron, Steel and Alloy - The Potassium Iodate Titration Method after Combustion in the Pipe Furnace for the Determination of Sulfur Content

GB/T 223.69 Iron, Steel and Alloy - Determination of Carbon Contents - Gas-volumetric Method after Combustion in the Pipe Furnace

GB/T 228.1 Metallic Materials - Tensile Testing - Part 1: Method of Test at Room Temperature

GB/T 229 Metallic Materials - Charpy Pendulum Impact Test Method

GB/T 230.1 Metallic Materials - Rockwell Hardness Test - Part 1: Test Method

GB/T 231.1 Metallic Materials - Brinell Hardness Test - Part 1: Test Method

GB/T 4336 Carbon and Low-alloy Steel - Determination of Multi-element Contents - Spark Discharge Atomic Emission Spectrometric Method (routine method)

GB/T 5611 Foundry Terminology

GB/T 5613 Designation for Cast Steels

GB/T 5677 Castings - Radiographic Testing

GB/T 5678 Sampling Methods of Spectrochemical Analysis for Cast Alloys

GB/T 6414 Castings - Dimensional Tolerances and Geometrical Tolerances and Machining Allowances

GB/T 7233.1 Steel Castings - Ultrasonic Testing - Part 1: Steel Castings for General Purposes

GB/T 9443 Steel and Iron Castings - Liquid Penetrant Inspection

GB/T 9444 Steel and Iron Castings - Magnetic Particle Inspection

GB/T 11351-2017 Mass Tolerances of Casting

GB/T 20066 Steel and Iron - Sampling and Preparation of Samples for the Determination of Chemical Composition

GB/T 39428 Steel Castings by Sand Casting - Visual Examination Method of Surface Quality

GB/T 40800 Specification and Qualification of Welding Procedures for Production Welding of Steel Castings

GB/T 40805-2021 Steel Castings - General Technical Delivery Requirements

3 Terms and Definitions

The terms and definitions defined in GB/T 5611, and the following are applicable to this document.

3.1 carbon equivalent

The content of alloying elements in steel is converted into the equivalent content of carbon in accordance with their effects, which is equal to the sum of the converted carbon content of various alloying elements and the actual total carbon content.

NOTE: carbon equivalent (CE) can be used as a reference index to evaluate the repair weldability of steel. Unless otherwise specified, the carbon equivalent is generally calculated in accordance with Formula (1).

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \quad \cdots\cdots (1)$$

Where,

C, Mn, Cr, Mo, V, Ni, Cu---the mass fraction of the element in steel, expressed in (%).

[source: GB/T 37681-2019, 3.10]

3.2 major defect

A defect with an excavation depth exceeding 25 mm or 40% of the wall thickness (whichever is smaller) or an excavation repair area greater than 64 cm^2.

4 General Conditions of Delivery

4.1 The delivered products shall comply with the requirements stated in the ordering information and additional materials in GB/T 40805-2021.

4.2 The supplementary requirements for delivered products shall be determined in the order contract, and the specific requirements shall comply with the provisions of Appendix C in GB/T 40805-2021.

5 Manufacturing Process

5.1 Casting

5.1.1 Unless the demand-side has special requirements, the smelting method of alloy materials shall be determined by the supply-side.

5.1.2 Unless the demand-side has special requirements, the casting and forming processes and methods shall be determined by the supply-side.

5.2 Heat Treatment

Unless the demand-side has special requirements, the heat treatment process shall be determined by the supply-side.

6 Technical Requirements

6.1 Chemical Composition

6.1.1 The method of designation expression of low alloy steel castings shall comply with the provisions of GB/T 5613.

6.1.2 The sulfur and phosphorus contents in the chemical composition of each material designation shall comply with the provisions of Table 1.

6.5.2 The machining allowances, dimensional tolerances and geometric tolerances of the castings shall comply with the requirements of the contract and drawings; if there are no requirements in the contract and drawings, the appropriate tolerance level shall be selected in accordance with the provisions of GB/T 6414.

6.6 Weight Tolerances

The weight tolerances shall comply with the drawings and technical requirements. If there are no special provisions, the weight tolerances shall comply with Level MT12 in GB/T 11351-2017.

6.7 Welding Repair

6.7.1 The welding repair of the castings shall comply with GB/T 40800. Unless otherwise specified, the welding process shall be determined by the supply-side.

6.7.2 Major welding repairs shall be approved by the demand-side in advance, and the location and size of the welding repairs shall be recorded.

6.7.3 If there are no special provisions, after major welding repairs, stress relief heat treatment shall be carried out. The temperature of the stress relief heat treatment shall be lower than the minimum tempering temperature of the previous heat treatment.

6.7.4 The welding repair area and surrounding areas shall be inspected in accordance with the inspection requirements of the body of this part.

6.8 Correction

The deformation caused by the castings can be eliminated through the method of correction. After correction, stress relief treatment shall be performed.

7 Test Methods

7.1 Chemical Composition Analysis

7.1.1 The chemical composition analysis method can be conventional chemical analysis or spectral analysis.

7.1.2 The sampling method of specimens for chemical composition analysis shall comply with the provisions of GB/T 20066. The sampling method of specimens for spectral analysis shall comply with the provisions of GB/T 5678.

7.1.3 The analysis of carbon, silicon, manganese, phosphorus and sulfur in the chemical composition shall respectively be carried out in accordance with the provisions of GB/T 223.69, GB/T 223.60, GB/T 223.4, GB/T 223.3, GB/T 223.68 or GB/T 4336.

7.1.4 The spectral analysis shall be carried out in accordance with the provisions of GB/T 4336.

7.1.5 Chemical analysis methods shall be selected for chemical composition arbitration.

7.2 Test of Mechanical Properties

7.2.1 Test blocks

7.2.1.1 The test blocks for mechanical properties shall be selected as single-cast test blocks or attached-casting test blocks as agreed upon by the demand-side and the supply-side. Unless otherwise specified, the selection of test block type shall be determined by the supply-side.

7.2.1.2 The shapes, dimensions and specimen cutting positions of single-cast test blocks shall comply with the requirements of Figure 1 in GB/T 40805-2021. Single-cast test blocks shall be cast from the same molding material as the casting they represent.

7.2.1.3 The shapes, dimensions, sampling positions and mechanical properties of attached-cast test blocks shall be agreed upon by the demand-side and the supply-side.

7.2.1.4 It is allowed to cut an appropriate gap for the attached-cast test blocks before heat treatment, but 10 mm ~ 30 mm can be retained to connect to the body. Before final properties heat treatment of the casting, the test blocks shall not be separated from the casting.

7.2.1.5 Unless otherwise specified, the test blocks and the casting they represent must be heat treated in the same furnace and marked.

7.2.1.6 When there are insufficient spare test blocks, sampling from the casting body is allowed. The sampling position and property indicators shall be agreed upon by the demand-side and the supply-side.

7.2.1.7 Unless otherwise specified, the thickness of the test blocks may refer to the thickness of the main section of the castings (expressed as t), which shall not be less than 28 mm thick. Sampling and analysis shall be carried out in accordance with the following provisions:

a) When the thickness of the test blocks is ≤ 56 mm, the distance between the axis center of the specimen and the casting surface shall not be less than 14 mm;

b) When the thickness of the test blocks is > 56 mm, the distance between the axis center of the specimen and the casting surface shall be $t/4 \sim t/3$, and not exceed 30 mm.

7.2.2 Tensile test

The tensile test shall be carried out in accordance with the provisions of GB/T 228.1.

7.2.3 Impact test

The impact test shall be carried out in accordance with the provisions of GB/T 229.

7.2.4 Hardness test

7.2.4.1 The Rockwell hardness test shall be carried out in accordance with the provisions of

GB/T 230.1.

7.2.4.2 The Brinell hardness test shall be carried out in accordance with the provisions of GB/T 231.1.

7.3 Surface Quality

7.3.1 The inspection of surface quality shall be carried out in accordance with the provisions of GB/T 39428. The inspection scope and level shall comply with the ordering requirements.

7.3.2 The penetrant inspection of the castings shall comply with the provisions of GB/T 9443.

7.3.3 The magnetic particle inspection of the castings shall comply with the provisions of GB/T 9444.

7.4 Geometrical Shape and Dimensional Inspection

7.4.1 To avoid disputes, dimensional inspection shall be performed in the shipped condition.

7.4.2 For the geometrical shape and dimensional inspection of the castings, inspection tools with corresponding accuracy shall be selected, and three-coordinate measuring instrument or other inspection methods can also be used.

7.5 Internal Quality

7.5.1 The ultrasonic testing of the castings shall be carried out in accordance with the provisions of GB/T 7233.1.

7.5.2 X-ray or γ-ray photography inspection of the castings shall be carried out in accordance with the provisions of GB/T 5677.

7.6 Welding Repair and Welding Qualification

The welding procedure qualification before welding repair of the castings shall be carried out in accordance with the provisions of GB/T 40800.

7.7 Correction

Casting correction shall adopt a pressure forming method.

8 Inspection Rules

8.1 Composition of Inspection Batch

One of the following circumstances may constitute an inspection batch.

a) In accordance with the smelting heat and heat treatment furnace: castings of the same material designation, the same smelting heat or multiple smelting heats, and the same

b) There are casting defects on the surface of the specimens or the specimens are improperly cut and machined (for example, specimen dimensions, transition fillet and roughness fail to comply with the requirements);

c) The specimens break outside the gauge length;

d) There are casting defects on the fracture surface after the specimens are broken.

8.3.4 If one of the above circumstances occurs, another specimen shall be taken from the same test block or other test blocks in the same furnace of molten steel for the test. The test result may replace the above invalid test results.

8.4 Re-inspection

When the initial test result is disqualified, unless otherwise specified, the supply-side shall comply with the following provisions.

a) For disqualified mechanical test (except impact test) items, take another two specimens and re-perform the mechanical test. If the result of one of the two specimens is disqualified, then, the supply-side may perform in accordance with 7.5.

b) For the impact test, if the average value of the three specimens does not reach the specified value, or one single value does not reach 70% of the specified value, or two are lower than the specified value, the supply-side may take another three specimens for the test from the same test block that was originally sampled, or from another test block representing the casting. Add the three test values to the original test value to re-calculate the average value. If the new average value satisfies the specified average value, then it can be determined as qualified. If the new average value still does not reach the specified value, or any of the new test values is lower than 70% of the lower limit of the specified value, or two of the new test values fail to reach the specified value, then, the supply-side may perform in accordance with 7.5.

8.5 Repeated Heat Treatment

When the properties in the initial inspection are disqualified, the castings and test blocks may be re-subjected to the heat treatment, then, the mechanical test can be performed. Without the consent of the demand-side, the castings and test blocks shall not be re-heated more than twice (except tempering).

8.6 Surface Quality

8.6.1 The surface quality of the castings shall be subjected to 100% visual inspection.

8.6.2 The frequency and quantity of magnetic particle inspection and penetrant inspection shall be agreed upon by the demand-side and the supply-side.

8.7 Internal Quality

The internal quality of the castings shall be subjected to non-destructive testing. The frequency and quantity of non-destructive testing shall be agreed upon by the demand-side and the supply-side.

8.8 Inspection of Geometrical Shapes, Dimensions, Dimensional Tolerances and Machining Allowances

The castings shall be inspected piece by piece or randomly inspected in accordance with the quantity agreed upon by the demand-side and the supply-side.

8.9 Welding Repair Inspection

The quality of welding repairs of the castings shall be inspected piece by piece or randomly inspected in accordance with the method agreed upon by the demand-side and the supply-side.

8.10 Correction Inspection

The quality of casting correction shall be inspected piece by piece.

9 Marking and Quality Certificate

9.1 Marking

9.1.1 If required by the demand-side and with the consent of the supply-side, each casting shall be properly marked. Unless otherwise specified by the demand-side, the position of the marking shall be determined by the supply-side. The content of the marking shall be as follows:

a) Supply-side identification;

b) Inspection batch identification;

c) Steel casting identification (heat No., designation, name or part No.);

d) Other markings required by the demand-side.

9.1.2 Small steel castings can be marked in batches, and the identification mark is hung on the plate of each batch of steel castings.

9.2 Quality Certificate

The supply-side shall provide the demand-side with a quality certificate signed by the person in charge of the supply-side's inspection department. The quality certificate shall at least include but not be limited to the following content:

a) Order contract No.;

b) Part drawing No. and name;

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