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**Heat resistant iron castings**

耐热铸铁件

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# Heat resistant iron castings

## 1 Scope

This Standard specifies the technical requirements, test methods, inspection rules, marks and quality certificates, anti-rust, packaging and storage requirements for heat resistant iron castings.

This Standard is applicable to heat resistant iron castings cast in sand molds or molds with similar thermal conductivity to sand molds and working at temperatures below 1100°C.

## 2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For dated references, the subsequent amendments (excluding corrigendum) or revisions do not apply to this Standard, however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 223.3, *Methods for chemical analysis of iron, steel and alloy - The dianthipyryl methane phosphomolybdate gravimetric method for the determination of phosphorus content*

GB/T 223.8, *Methods for chemical analysis of iron, steel and alloy - The sodium fluoride separation - EDTA titration method for the determination of aluminum content*

GB/T 223.11, *Iron, steel and alloy - Determination of chromium content - Visual titration or potentiometric titration method*

GB/T 223.12, *Methods for chemical analysis of iron, steel and alloy - The sodium carbonate separation-diphenyl carbazide photometric method for the determination of chromium content*

GB/T 223.26, *Iron, steel and alloy - Determination of molybdenum content - The thiocyanate spectrophotometric method*

GB/T 223.28, *Methods for chemical analysis of iron, steel and alloy - The  $\alpha$ -benzoin oxime gravimetric method for the determination of molybdenum content*

GB/T 223.58, *Methods for chemical analysis of iron, steel and alloy - The sodium*

*arsenate-sodium nitrite titrimetric method for the determination of manganese content*

*GB/T 223.59, Iron, steel and alloy - Determination of phosphorus content - Bismuth phosphomolybdate blue spectrophotometric method and antimony phosphomolybdate blue spectrophotometric 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 223.61, Methods for chemical analysis of iron, steel and alloy - The ammonium phosphomolybdate volumetric method for the determination of phosphorus content*

*GB/T 223.64, Iron, steel and alloy - Determination of manganese content - Flame atomic absorption spectrometric method*

*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, Metallic materials - Tensile testing*

*GB/T 231.1, Metallic materials - Brinell hardness test - Part 1: Test method*

*GB/T 4338, Metallic materials - Tensile testing at elevated temperature*

*GB/T 5612, Code for representing cast iron*

*GB/T 5677, Castings - Radiographic testing*

*GB/T 5678, Sampling methods of spectrochemical analysis for cast alloys*

*GB/T 6060.1, Surface roughness comparison specimen - Part 1: Casting surface*

*GB/T 6414, Castings - Dimensional tolerances and geometrical tolerances and machining allowances*

*GB/T 7216, Metallographic test for gray cast iron*

*GB/T 7233, Methods for ultrasonic testing and for specifying quality levels of steel castings*

*GB/T 9441, Metallographic test method for spheroidal graphite cast iron*

*GB/T 9444, Steel and iron castings - Magnetic particle inspection*

### 3.3 Surface quality

**3.3.1** The surface roughness of castings shall meet the requirements of GB/T 6060.1. The standard level is agreed upon by the supplier and the purchaser.

**3.3.2** Castings shall be cleaned. Trim the excessive part. Remove the residue of the pouring riser, the core bone, the sticky sand and the residue of the inner cavity. The allowable riser residue, drape, flying spur residue, inner cavity cleanliness of the casting shall comply with the purchaser's drawing, technical requirements or order agreement between the supplier and the purchaser.

**3.3.3** The shape, quantity, size and position of the allowable defects on the casting, whether they can be repaired, and the method of repairing shall be agreed upon by the supplier and the purchaser.

### 3.4 Mechanical properties

The mechanical properties of castings at room temperature shall meet the requirements in Table 2. See Annex A for short-time high temperature tensile properties.

### 3.5 Heat treatment

Silicon-based and aluminum-based heat resistant ductile iron castings shall generally undergo heat treatment to eliminate residual stress. However, when the silicon-molybdenum heat resistant ductile iron castings have a pearlite content of less than 15%, heat treatment is not required. For other designations, if required by the purchaser, the heat treatment for eliminating residual stress shall be carried out according to the order conditions.

See Annex B for the service conditions of heat resistant cast iron.

### 3.6 Metallographic structure

For the metallographic structure of heat resistant cast iron, refer to the provisions of GB/T 9441 and GB/T 7216. The specific requirements shall be negotiated by both parties. For silicon-based heat resistant cast iron, the matrix structure shall be mainly ferrite.

### 3.7 Anti-oxidation, anti-growth properties and thermal expansion coefficient

At the service temperature, the average oxidation weight gain rate of heat resistant cast iron is not greater than  $0.5\text{g/m}^2\cdot\text{h}$ ; the growth rate is not greater than 0.2%.

The anti-oxidation and anti-growth properties and thermal expansion coefficient of heat resistant cast iron are not used as the basis for acceptance.

**4.2.1** The room temperature mechanical property test of HTRCr, HTRCr2, HTRSi5 and other designations, including the preparation of specimens, shall be carried out in accordance with the provisions of GB/T 228.

**4.2.2** The mechanical property tests at room temperature of each designation of heat resistant ductile iron and HTRCr16 shall be carried out in accordance with the provisions of GB/T 228.

**4.2.3** The hardness determination of heat resistant cast iron shall be carried out in accordance with the provisions of GB/T 231.1.

**4.2.4** The determination of short-time high-temperature tensile strength of heat resistant cast iron shall be carried out in accordance with the provisions of GB/T 4338.

### **4.3 Test blocks, specimens**

**4.3.1** The shape and size of the Y-shaped single-cast test block used in the tensile test of QTRSi4, QTRSi5, QTRSi4Mo, QTRSi4Mo1, QTRAl4Si4, and QTRAl5Si5 are shown in Figure 1 and Table 3 (the hatched line in Figure 1 is the position where the specimen is cut). Generally, choose type II. The test blocks in Annex C can also be used. The shape and size of single-cast easy-cut test blocks used by QTRAl22 and HTRCr16 are shown in Figure 2.

**4.3.2** Figure 3 and Table 4 show the shapes and dimensions of the tensile specimens used for each heat resistant ductile iron designation and HTRCr16 designation.

**4.3.3** The test block shall be poured with molten iron in the same package as the casting and poured at the end. Its cooling method is as consistent as possible with the casting.

**4.3.4** The boxing temperature of the test block shall not be higher than 500°C.

**4.3.5** It is allowed to take specimens from the attached casting test block or directly on the casting. The acceptance value shall be agreed upon by the supplier and the purchaser.

### **4.4 Anti-oxidation and anti-growth test**

Anti-oxidation and anti-growth tests of heat resistant cast iron shall be carried out in accordance with the provisions of Annex D and Annex E.

### **4.5 Thermal expansion coefficient test**

Refer to Annex F for the test method of thermal expansion coefficient.

alone.

**5.1.4** During a certain time interval, if there is a change in charge, process conditions or required chemical composition, all castings poured from continuously molten iron during this period, no matter how short the time interval is, are taken as a sampling batch.

**5.1.5** When continuously melting a large amount of molten iron of the same designation, the maximum weight of each sampling batch shall not exceed the weight of castings poured within 2h.

**5.1.6** When the weight of molten iron is less than 2000kg, the castings poured from this batch of molten iron can be regarded as a sampling batch.

**5.1.7** Upon negotiation between the supplier and the purchaser, several batches of castings can also be combined into a group for acceptance.

In this case, there shall be other quality control methods in the production process, such as rapid chemical composition analysis, metallographic inspection, non-destructive testing, fracture inspection. It is indeed proved that each spheroidization treatment is stable and meets the process requirements.

**NOTE:** Heat-treated castings shall be tested in the same sampling batch, unless the castings in the batch are significantly different in structure. In this case, these structurally distinct castings constitute a sampling batch.

## **5.2 Sampling for chemical composition**

Each sampling batch shall be analyzed once for chemical composition. The analysis results shall meet the requirements in Table 1. If the chemical composition is unqualified, it is allowed to re-analyze with double the number of specimens. The specimens are considered accepted only when they are all qualified.

## **5.3 Sampling for casting size**

The first batch of castings and important castings shall be checked on each piece for size, geometry and surface roughness. General castings can be spot-checked. The method of spot check shall be agreed upon by the supplier and the purchaser.

## **5.4 Appearance quality sampling inspection**

The appearance quality of casting shall be visually inspected piece by piece.

## **5.5 Sampling inspection of mechanical properties, metallographic structure, anti-oxidation and anti-growth properties**

The room temperature mechanical properties of heat resistant ductile iron shall be checked by batch. The mechanical properties at room temperature of the rest of the heat

resistant cast iron and the metallographic structure, anti-oxidation, and anti-growth of all designations are tested according to the order conditions.

The mechanical properties at room temperature are based on the tensile strength. If the ordering conditions require testing hardness, it shall meet the requirements of Table 2.

To ensure that the castings and test bars have the same heat or package number, the heat or package number shall be clearly marked on the non-important surface of the specimen and casting.

### **5.6 Evaluation of mechanical performance test results**

When testing the tensile strength, if the test result of the first tensile sample fails to meet the requirements, and it is not caused by the reasons listed in 5.7, then two other specimens from the same batch can be taken for reinspection.

If the reinspection results meet the requirements, the material of this batch of castings is still accepted. If one of the reinspection results still fails to meet the requirements, the batch of castings is initially judged to be rejected in material. At this time, one piece of castings can be randomly selected from the batch, and the body specimen can be cut from the position agreed by both the supplier and the purchaser for mechanical performance testing. If the testing results meet the requirements, it can still be judged that the material of this batch of castings is accepted. If the test result of the body specimen still fails to meet the requirements, the material of this batch of castings will be finally judged as rejected.

### **5.7 Validity of test**

If the test result does not meet the requirements due to one of the following reasons rather than the quality of the casting itself, the test shall be invalid.

- a) Improper clamping of the specimen on the testing machine or improper operation of the testing machine.
- b) Casting defects on the surface of the specimen or improper cutting and processing of the specimen (such as specimen size, transition fillet, roughness does not meet the requirements).
- c) Tensile specimen break outside the gauge length.
- d) Obvious casting defects on the fracture surface of tensile specimen.

In the above cases, a new specimen shall be made on the same test block, or the specimen shall be re-processed from the same batch of poured test block for reinspection. The results of the reinspection replace the results of the invalid test.

### **5.8 Heat treatment of test blocks and castings**



## **Annex D**

(informative)

### **Test method for resistance to growth of heat resistant cast iron**

This method is suitable for determining the anti-growth of various heat resistant cast irons in high-temperature air medium.

#### **D.1 Basic requirements for test equipment and conditions for resistance to growth**

**D.1.1** The anti-growth test furnace shall meet the following requirements:

- a) There is an automatic temperature adjustment device. Its accuracy is  $\pm 5^{\circ}\text{C}$ ;
- b) The temperature difference of each point in the specimen distribution area in the furnace shall not exceed  $\pm 5^{\circ}\text{C}$ ;
- c) Keep an adequate oxidizing atmosphere in the furnace.

**D.1.2** There is enough space between the specimens placed in the furnace, so as to ensure good contact between the air in the furnace and the surface of the specimens.

**D.1.3** After the specimen is loaded into the furnace, the time for the furnace to reach the specified temperature is regarded as the start of the test. When the specified test period expires, the time when the furnace stops working (or the specimen is taken out) is regarded as the end of the test.

#### **D.2 Specimen shape, measurement accessories and test preparation**

**D.2.1** For the anti-growth test, cylindrical specimens shall be used (Figure D.1). The specimen size shall be: diameter of 20mm ~ 25mm; length of 100mm ~ 150mm.

**D.2.2** The surface roughness of the specimen shall be less than  $12.5\mu\text{m}$ . Both ends shall remain parallel.

**D.2.3** Two measuring screws can be installed at both ends of the specimen. Its dimensions can refer to Figure D. 2 (if the measuring screw is not used, the end surface of the specimen can be chrome-plated or nickel-plated; there is no need to drill screw holes at both ends of the specimen at this time).

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