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**Test method for qualified work zone of heat treatment  
furnace**

热处理炉有效加热区测定方法

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# Test method for qualified work zone of heat treatment furnace

## 1 Scope

This document specifies the requirements for classification of heat treatment furnaces according to temperature uniformity, initial test and periodic test of qualified work zones, test systems, test methods, result evaluation, records and reports, and management.

This document is suitable for determining the qualified work zone of a heat treatment furnace that meets temperature uniformity requirements within the operating temperature range. This document does not apply to work zones in continuous heating furnaces where there is no fixed process-specified heating temperature or where temperature uniformity is not required. This document can be used as a reference for other heating equipment.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 1598, *Platinum-10% Rhodium/Platinum thermocouple wires -- Platinum-13% Rhodium/Platinum thermocouple wires -- Platinum-30% Rhodium/Platinum-6% Rhodium thermocouple wires*

GB/T 2614, *Nickel-Chromium/Nickel-Silicon thermocouple wires*

GB/T 2903, *Copper/Copper-Nickel (Constantan) thermocouple wires*

GB/T 4989, *Extension and compensating cables for thermocouples*

GB/T 4990, *Alloy wires of extension and compensating cables for thermocouples*

GB/T 4993, *Nickel-Chromium/Copper-Nickel (Constantan) thermocouple wires*

GB/T 4994, *Iron/Copper-Nickel (Constantan) thermocouple wires*

GB/T 5977, *Platinum wires for resistance thermometers*

GB/T 7232, *Metal heat treatment - Terminology*

GB/T 13324, *Terminology of heat treatment equipment*

GB/T 16839.1, *Thermocouples -- Part 1: EMF specifications and tolerances*

GB/T 17615, *Nickel-Chromium-Silicon/Nickel-Silicon-Magnesium thermocouple wires*

GB/T 18404, *Mineral insulated metal-sheathed thermocouple cables and thermocouples*

GB/T 30825, *Pyrometry for heat treatment*

JB/T 8901, *Sheathed noble metal thermocouple cables*

### **3 Terms and definitions**

For the purposes of this document, the terms and definitions defined in GB/T 7232, GB/T 13324 and GB/T 30825 as well as the followings apply.

#### **3.1 process temperature**

The heating temperature specified by the heat treatment process is based on the purpose of heat treatment of the workpiece and the type of material.

#### **3.2 temperature uniformity**

The degree of temperature uniformity in the qualified work zone of the heat treatment furnace refers to the maximum deviation of the temperature of each test point in the qualified work zone relative to the set temperature.

**NOTE:** Usually it is expressed as " $\pm^{\circ}\text{C}$ ".

#### **3.3 qualified work zone**

In the heating furnace, the working space that meets the process temperature and temperature uniformity specified by the heat treatment is determined through temperature detection.

#### **3.4 previewed qualified work zone**

In order to judge the qualified work zone of the heat treatment furnace, before testing, it is a pre-assumed temperature measurement space based on the structure, control method and other conditions of the heat treatment furnace. It is generally a work space stipulated by the heat treatment furnace manufacturer or relevant standards.

#### **3.5 no load test**

A test to determine the qualified work zone without loading workpieces or substitutes

into the heat treatment furnace.

### **3.6 load test**

A test to determine the qualified work zone when the workpiece or substitute is loaded into the heat treatment furnace.

### **3.7 initial test**

It is a qualified work zone test that is performed to determine the qualified operating area, operating temperature range and furnace category for heat treatment furnaces that are newly put into production or have undergone overhaul, technical transformation, and repairs, changes, and adjustments during use.

### **3.8 periodic test**

A qualified work zone test that is carried out regularly at a certain frequency during the use of the heat treatment furnace.

### **3.9 stabilization**

All control and recording sensor temperatures are within the allowable uniformity deviation range, and the temperature control of each zone is maintained at the set temperature to achieve equipment stability. All qualified work zones determine that the sensor temperature reaches the required uniformity range. And it can be determined that the temperature of all sensors does not show a continuous trend of upward or downward deviation from the set point, and the temperature uniformity measurement is stable.

## **4 Classification of heat treatment furnaces according to temperature uniformity**

**4.1** Heat treatment furnaces are divided into seven categories according to the temperature uniformity of the qualified work zone. The corresponding temperature control instrument accuracy level and digital recording instrument accuracy level are shown in Table 1.

- be moved on wheels or other portable means);
- b) When the position of the qualified work zone changes or the volume expands;
  - c) When the operating temperature range is extended;
  - d) When there are changes in furnace gas flow pattern and speed (such as baffle position, wind speed, air volume, etc.);
  - e) When there are changes in type or thickness of refractory materials;
  - f) When the number, type or location of heating elements is changed;
  - g) When burner size, number, type or location changes;
  - h) When the vacuum furnace hot zone design or materials change;
  - i) When the temperature control sensor changes (such as type, specification, structure) and location changes;
  - j) When the combustion pressure setting changes;
  - k) When the furnace pressure setting changes;
  - l) When the setting parameters of the control instrument are changed;
  - m) When the production objects or processes of the heat treatment furnace are changed, the temperature uniformity of the qualified work zone needs to be improved;
  - n) When heat-treated products appear unqualified, it is found to be related to temperature uniformity;
  - o) When a heat treatment furnace that exceeds the specified testing period and has not been used for more than three consecutive months is reactivated.

## **5.2 Periodic test**

**5.2.1** During the use of the heat treatment furnace, the qualified work zone shall be periodically tested. The test period shall comply with the requirements in Table 3.

and the data recorder installed in the heat insulation box into the furnace. The data recorder will automatically track and record the temperature of each test point.

## **7 Test methods**

### **7.1 General requirements**

**7.1.1** Under normal circumstances, no load test or load test can be used during testing. If it is a no load test, the measuring temperature sensor can be used directly for testing, or the measuring temperature sensor can be connected or inserted into the test block. The thickness of the test block shall be less than or equal to the thickness of the thinnest workpiece in the furnace. The maximum thickness shall not exceed 13 mm. The material of the test block shall have a room temperature thermal conductivity similar to that of the main material of the workpiece in the heat treatment furnace. If it is a load test, the test temperature sensor shall be connected to the dummy or workpiece. The simulated piece shall represent the thickness of the workpiece processed in the furnace.

**7.1.2** The heat treatment furnace is in normal working condition during the test. Warm up at normal rate. The fan operates normally. The furnace door of the mesh belt furnace is in a normal opening and closing state.

**7.1.3** The atmosphere used in the heat treatment furnace shall be the normal atmosphere used in production. For temperature sensors that are prone to contamination (for example, carburizing, nitriding, endothermic and exothermic atmospheres) or process atmospheres that pose safety risks (for example, atmospheres containing hydrogen or ammonia), air or an inert atmosphere can be used instead. The vacuum degree of the vacuum furnace shall be the lowest vacuum degree used in production, but the vacuum pressure shall not be less than 0.13 Pa.

**7.1.4** When the workpiece is hot loaded into the furnace, the temperature at which the test temperature sensor is placed into the furnace shall not exceed the test temperature. When the process requires that the workpiece is cold and the furnace heats up, the test temperature sensor shall also heat up with the furnace.

**7.1.5** A heat treatment furnace can have multiple qualified work zones. For multiple operating temperature ranges with different temperature uniformity requirements, or multiple qualified work zones with different temperature uniformity requirements, temperature uniformity measurements shall be performed separately.

### **7.2 Test temperatures**

#### **7.2.1 Initial test**

The test temperatures for the initial test of the qualified work zone shall be the highest and lowest temperatures of each operating temperature range. When the operating temperature range is greater than 335°C, the test temperature point shall be added

## **7 Test steps**

### **7.4.1 Test preparation**

The measuring instruments and test sensors used for qualified work zone testing shall comply with the provisions of this document, be qualified in verification or calibration, and be within the effective period of use. The verification or calibration certificate of measuring instruments and test sensors shall indicate the correction value or error value at each verification or calibration temperature.

### **7.4.2 Sensor installation**

**7.4.2.1** According to the test temperature, select appropriate metal wire or other materials to fix the measurement sensor. If galvanized iron wire is used to fix the measuring sensor, the galvanized layer shall be removed in advance. When testing a vacuum furnace, stainless steel wire or nickel-based alloy wire shall be used to fix the measuring sensor.

**7.4.2.2** When using a temperature measuring stand, each measuring sensor shall be fixed on the temperature measuring stand in a suitable manner to ensure that the measuring end of the sensor is at the specified position and the position does not change during the test.

**7.4.2.3** When the measuring sensor or material rack with a temperature measuring frame is fixed, it can be placed in the furnace under cold furnace conditions according to process requirements. It can also be placed in the furnace at any temperature within the lower limit of the allowable temperature deviation from the lowest test temperature point.

**7.4.2.4** Lead the reference end of the measuring sensor from the special temperature measuring hole of the heat treatment furnace. When leading out the reference end, prevent damage to the sealing and heat preservation properties of the heat treatment furnace. At the same time, the measuring sensor shall be prevented from being damaged by extrusion.

### **7.4.3 Sensor and instrument connection**

**7.4.3.1** Sensors and instruments are generally connected in the following three ways:

- a) The sensor reference terminal is directly connected to the input terminal of the instrument or data acquisition processor;

- b) The sensor reference terminal is connected to one end of the compensation wire. The other end of the compensation wire is connected to the input terminal of the measuring instrument or data acquisition processor;
- c) The sensor reference terminal is connected to the multi-channel automatic (scanning) switch input terminal of the measuring system device directly or through a compensation wire.

**7.4.3.2** When the sensor is connected to the instrument, it shall be ensured that each terminal does not generate additional thermal electromotive force or resistance (the additional thermal electromotive force or resistance is small enough) to ensure the accuracy and reliability of the measurement results.

**7.4.3.3** When connecting components such as connectors, plugs and sockets (including pins), terminal blocks or wiring boards are used for connection, it shall be ensured that the thermoelectric characteristics of these components are the same as or compatible with the measuring sensor.

#### **7.4.4 Data collection and processing**

**7.4.4.1** When testing temperature uniformity, data collection and recording shall start before the temperature of the first test sensor reaches the lower limit of the allowed deviation of the required temperature uniformity.

**7.4.4.2** After the heat treatment furnace reaches a steady state, the collected data can be recorded in Table A.1 of Annex A. The collection time or frequency shall comply with the requirements in Table 10.

**7.4.4.3** The effective data of the measuring sensor is corrected according to the correction value (or error value) of the corresponding temperature point of each measuring sensor, compensation wire and measuring instrument. Obtain the actual temperature value of each measurement position at each test temperature point.

**7.4.4.4** For each test temperature point, use the difference between the actual temperature value of each measurement position and the test temperature set value as the temperature deviation value of the test position. Determine the maximum and minimum temperature deviation values for each test temperature.

**7.4.4.5** When performing error correction, if the verification or calibration temperature point of the measuring sensor or measuring instrument does not correspond to the specified qualified work zone test temperature point, the error value of the verification

sensor.

## 8 Evaluation of qualified work zone test

**8.1** Through testing, it is assumed that when the actual temperatures of each test point in the qualified work zone are within the temperature uniformity range specified by the process, that is, the temperature uniformity is qualified, then this space is the qualified work zone of the process.

**8.2** Based on the temperature uniformity test results, refer to Table 1 to determine the type of heat treatment furnace.

**8.3** For the data measured according to the method specified in this document, if the temperature uniformity of one test point cannot meet the requirements, the measurement of the qualified work zone will fail. The assumed qualified work zone shall be changed or the heat treatment furnace shall be adjusted and retested. For example, when using a heat treatment furnace that lowers the furnace temperature uniformity requirements, repeated testing is not required as long as the new temperature uniformity conditions are met.

## 9 Records and reports

**9.1** All original records during the testing process shall be retained (see Table A.1). The original record shall contain the following content:

- a) The name, model, equipment number, and category of the heat treatment furnace;
- b) The no load or load condition of the equipment under test and the loading amount of the loading test;
- c) The type of atmosphere or salt bath used by the device under test;
- d) Operating temperature range, test temperature and temperature uniformity requirements of the equipment under test;
- e) Configuration type of process instrumentation of the equipment under test;
- f) The name, model, accuracy level, error value and validity period of the measuring instrument;
- g) Correction values for all measuring sensors;
- h) A schematic diagram (three-dimensional view or plan view) of the pre-specified or determined qualified work zone shape, size and sensor arrangement location;
- i) Whether all measuring sensors use temperature test blocks and the shape and

specifications of the test blocks;

- j) Time, temperature data or/and temperature curves recorded by all test area measurement sensors and process sensors (excluding alarm sensors);
- k) The time when each test temperature point starts and ends the temperature measurement, the temperature display value and the actual temperature value after data processing;
- l) The temperature deviation values of all measuring sensors after data processing at each test temperature point;
- m) Qualified work zone test and evaluation conclusion;
- n) Test start and end date and time, validity period and next due date of test;
- o) Signature of the responsible person (tester, reviewer).

**9.2** Based on the original records, a test report for qualified work zone is formed, including:

- a) Name, number, category, manufacturer, and model of the heat treatment furnace;
- b) No load or load conditions and loading amounts for loading tests;
- c) Operating temperature, test temperature and temperature uniformity;
- d) Name and accuracy of the temperature measuring instrument;
- e) Type of atmosphere or salt bath used (composition, characteristics);
- f) Loading capacity, furnace loading type, material transport speed, workpiece characteristics (material, shape, size and weight, etc.) of the loading test;
- g) Maximum temperature deviation value of each test point;
- h) Evaluation results of qualified work zone;
- i) Test date and next test date;
- j) Name and signature of the responsible person (tester, reviewer, approver), testing agency and seal;
- k) Test certificate of qualified work zone (see Table B.1 in Annex B).

## **10 Management**

**10.1** All original records and documentation of the qualified work zone testing process

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