GB

NATIONAL STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

ICS 25.180.10

K 60

GB/T 7287-2008

Replacing GB/T 7287.1 ~ GB/T 7287.12-1987

Test method of infrared heater

红外辐射加热器试验方法

Issued on: June 30, 2008 **Implemented on: April 01, 2009**

Issued by: General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China;

Standardization Administration of the People's Republic of China.

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Foreword

This standard replaces GB/T 7287.1 ~ GB/T 7287.12-1987 “Test method of infrared heater”. As compared with the latter, the main changes of this standard are as follows:

- In accordance with the development of infrared heater manufacturing and testing technology, EXTEND the scope of application from the medium temperature infrared heater to a variety of low temperature, medium temperature and high temperature infrared heater.

- ADD three parts: “Normative references”, “Terms and definitions”, and “Product classifications”.

- In accordance with the changes of relevant standard, ADD the test methods of such performance indicators as “leakage current and electrical strength at working temperature”, “moisture resistance”, “effective radiation energy ratio and distribution temperature”, “terminal tensile force”, “mechanical strength”, “bending test”, “peel strength”, “flame retardant performance”, “low temperature storage”, and “overload capacity”, and so on.

- As for the measurement of normal total emissivity, ADD the “thermal image measurement method” (method B) on the basis of the “relative radiometer method”.

- As for the electrical heat radiation conversion efficiency, ADD the “thermal image measurement method” (method B) and the “distribution radiancy method” (method C) on the basis of the "radiometer method".

This standard was proposed by China Electrical Equipment Industry Association.

This standard shall be under the jurisdiction of the National Industrial Electrical Heating Equipment Standardization Technical Committee (SAC/TC 121).

The drafting organizations of this standard: National Infrared and Industrial Electrical Heating Product Quality Supervision and Inspection Center, Yangzhong Datang Electric Manufacturing Co., Ltd., Nanjing Lishui Best Co., Ltd.

The main drafters of this standard: Zeng Yu, Xiong Jie, Ye Ping, Li Gang, Tang Ruixian, Wei Siping.

This Standard replaces the standard previously issued as follows:

- GB/T 7287.1 ~ 7287.12-1987.

Test method of infrared heater

1 Scope

This standard specifies the performance test method for infrared heaters (hereinafter shortly referred to as “heaters”).

This standard applies to the infrared heaters, including various low temperature, medium temperature and high temperature metallic matrix or non-metallic matrix electrical infrared heaters.

This standard describes the basic characteristics of infrared heaters AND specifies the methods to test these characteristics, for reference by the user.

2 Normative references

The provisions in following documents become the provisions of this Standard through reference in this Standard. For the dated references, the subsequent amendments (excluding corrections) 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 2423.10-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test Fc: Vibration (sinusoidal) (IEC 60068-2-6:1995, IDT)

GB/T 2900.23-2008 Electrotechnical terminology - Industrial electroheat (IEC 60050-841:2004, IDT)

GB 4706.1-2005 Household and similar electrical appliances - Safety - Part 1: General requirements (IEC 603351:2001, IDT)

GB 4706.8-2003 Household and similar electrical appliances - Safety - Particular requirements for blankets pads and similar flexible heating appliances (IEC 60335.21:1998, IDT)

GB/T 8808-1988 Test method for peeling of soft composite plastic materials (neq DIN 53357:1982)

GB/T 10066.1-2004 Test methods for electroheat installations - Part 1: Generic (IEC 60398:1999, MOD)

GB/T 10066.12-2006 Test methods for electroheat installations - Part 12: Infrared heating installations

QB/T 2057-2006 Infrared lamps

3 Terms and definitions

The terms and definitions as defined in GB/T 2900.23-2008 and GB/T 10066.12-2006 AND the following terms and definitions apply to this part.

3.1

Infrared heater

It refers to the heater which converts the input energy mainly into the infrared radiant energy.

3.2

Conditions of adequate heat discharge

It refers to the working state of the heater under normal use conditions.

3.3

Condition of adequate heated

It refers to the working state of the heater which reaches to the thermal balance through energization and temperature rise under the normal use conditions.

3.4

Working temperature

It refers to the average temperature of the radiant surface at which the heater is operated at the rated voltage and under the conditions of adequate heat discharge.

3.5

Electric-to-radiant power transfer efficiency

It refers to, after the heater being operated at rated voltage to achieve thermal balance, the percentage of converting the input electrical power into the total radiant flux.

3.6

Ratio for effective radiant power

It refers to the ratio of the radiant flux in the effective infrared spectrum band (1 μm ~ 25 μm) to the total radiant flux.

3.7

Temperature rise time

It shall specify the type structure of the heater.

4.3 Classification by working temperature of the product

- Low temperature heater (< 200 °C);
- Medium temperature heater (200 ~ 600 °C);
- High temperature heater (> 600 °C).

It shall specify the working temperature range of the heater.

5 Test items

5.1 Testing of the dimension, shape and appearance of the heater (Chapter 7);

5.2 Measurement of the surface temperature distribution of the heater (Chapter 8);

5.3 Measurement of ratio of heater radiant surface to the back surface temperature (Chapter 9);

5.4 Measurement of temperature rise time of the heater (Chapter 10);

5.5 Measurement of heater power deviation (Chapter 11);

5.6 Test of leakage current and electrical strength of heater at working temperature (Chapter 12);

5.7 Test of moisture resistance of heater (Chapter 13);

5.8 Test of leakage current and electrical strength of heater (Chapter 14);

5.9 Measurement of insulation resistance of heater (Chapter 15);

5.10 Test of alternating cold-hot resistance of heater (Chapter 16);

5.11 Measurement of electric-to-radiant power transfer efficiency of heater (Chapter 17);

5.12 Measurement of normal total emissivity of heater (Chapter 18);

5.13 Measurement of normal spectral emissivity of heater (Chapter 19);

5.14 Measurement of effective radiant energy ratio, distribution temperature, and radiant wavelength range of the heater (Chapter 20);

5.15 Tensile test of heater terminals (Chapter 21);

5.16 Test of the service life of the heater (Chapter 22);

As for the diameter measurement, USE the vernier caliper to conduct measurement at the middle part at both opposite sides.

7.2.1.3 Measurement of radiant matrix plate flatness of plate and rectangular heater

USE the plate as the reference plane; PLACE the test piece on the plate; USE the feeler to measure the maximum clearance between the bottom surface of the test piece and the reference plane.

7.2.1.4 Measurement of matrix center axis straightness of tubular and lamp heater

PLACE the test piece on the plate; USE the feeler to conduct measurement at the maximum matrix bending position of the heater; READ out the maximum value; MAKE calculation in accordance with the total length percentage; AND the results shall comply with the requirements of the relevant standards for the matrix axis straightness error.

7.2.2 Visual inspection

It shall comply with the provisions of relevant standards; USE visual inspection to check its conformance.

8 Measurement method of surface temperature distribution of heater

8.1 Measuring instruments

Radiation thermometer or other thermometers and their supporting devices, the accuracy shall comply with the requirements of 5.7 in GB/T 10066.1-2004, AND the temperature measurement range shall be in consistent with the working temperature range of the heater under measurement.

8.2 Measurement method

8.2.1 Determination of temperature measurement point

The temperature measurement point of the plate and rectangular heater shall be as shown in Figure 1.

APPLY the rated working voltage to the sample to raise the temperature. When it reaches to the steady state (as defined in Chapter 10), the value shown on the electrical power meter is the measured power of the sample. During the process of temperature rise, it is required to use the voltmeter to monitor the rated working voltage which is applied onto the sample.

The power deviation rate is calculated in accordance with the formula (3):

$$J = \frac{P - P_h}{P_h} \times 100\% \qquad \cdots\cdots(3)$$

Where:

J - Power deviation rate, which is dimensionless;

P - Measured electrical power, in watts (W);

P_h - Rated electrical power, in watts (W).

12 Test method for leakage current and electrical strength of the heater at working temperature

12.1 Measuring instruments

The voltmeter having an accuracy of not less than level 0.5, the milliampere ammeter having an accuracy of not less than level 0.5, AND the insulation withstand voltage test bench.

12.2 Measurement method

The test is carried out when the heater is energized and reaching to a steady state.

ENERGIZE the heater under the normal working state; ADJUST the supply voltage to make the input power equal to 1.15 times the rated power. CONDUCT test when the working temperature of the heater reaches to stable state.

12.2.1 Measurement of leakage current at working temperature

The electrical circuit schematic diagram for measurement is as shown in Figure 5:

I_H - Action current, in milliamps (mA);

U_H - Test voltage, in volts (V);

R_H-120, in kilohertz (kΩ).

The action current shall be rounded off to an integer value.

13 Test methods of moisture resistance of heater

13.1 Test instrument

Wet test chamber, insulation withstand voltage test bench, milliampere ammeter, and other measuring instruments.

13.2 Test method

PLACE the heater which had been subjected to the corresponding tests in the laboratory having a usual atmospheric environment for 24 hours; START conducting this test.

The heater shall be placed in the test chamber in a non-packaged, non-energized, “ready-to-use” and normal working position or in accordance with the relevant standards.

MAKE the heater be subjected to the wet treatment in a humid chamber having a relative humidity of (93 ± 2)% for 48 h. The temperature of the air is kept within 1K of any convenient value t between 20 °C and 30 °C. Before placing it in the test chamber, MAKE the sample reach to the temperature t.

After this treatment, MAKE the heater immediately subjected to the leakage current and electrical strength test in the original wet chamber OR in a room which makes the sample reach to the specified temperature.

The test method of leakage current and electrical strength after moisture resistance test shall be carried out in accordance with the provisions of Clause 14.

14 Test method of leakage current and electrical strength of heater

14.1 Test instrument

The voltmeter having an accuracy of not less than level 0.5, the milliampere ammeter having an accuracy of not less than level 0.5, AND the insulation withstand voltage test bench.

14.2 Test methods

MAKE the radiant surface under measurement to able to be subjected to point source approximation as relative to the detector.

The photosensitive surface of the radiation power meter detector, the light bar plane, and the measurement plane of the heater shall be parallel with each other AND be coaxial.

ADJUST beam defining light bar, so that the measured radiant surface is filled with the field of view of the detector.

17.1.2.4 Power measurement

TURN on the power supply; after it reaches to the temperature rise time, MEASURE and RECORD the electrical power value P_e.

Consecutively MEASURE and RECORD the radiant power value P_i of each measurement point.

17.1.3 Calculation of measurement results

17.1.3.1 Calculation of radiation area

CALCULATE the area of the radiant surface (m^2) in accordance with the measured value of 17.1.2.1.

17.1.3.2 Calculation of radiant exitance

Under the condition of satisfying Lamber radiator, the radiant exitance is calculated in accordance with the formula (5)

$$M = \frac{16}{\pi} \cdot \left(\frac{L}{d_1 \cdot d_2}\right)^2 \cdot \frac{\sum_{i=1}^{n} P_i}{n} \qquad \cdots\cdots (5)$$

Where:

M - Radiant exitance, in watts per square meter (W/m^2);

L - The distance between the photosensitive surface of the detector and the light bar, in meters (m);

d_1 -The diameter of the beam defining light bar, in meters (m);

d_2 - The light bar diameter, in meters (m);

Pi - The measured value of the radiant power at the i^{th} point on the radiant surface, in watts (W);

Where: the size of L, d_1 and d_2 are determined by reference to 17.1.2.3.

17.1.3.3 Calculation of conversion efficiency

4 - Water-cooled light bar;

5 - Beam defining light bar;

6 - Modulator;

7 - Detector;

8 - Amplification system;

9 - mV meter.

Figure 10 -- Schematics of normal total emissivity measuring device

18.1.1.2 Instruments and equipment

Temperature controller: temperature control accuracy is not less than ± 0.5 K.

Sample rack: it can easily hold a variety of heaters, AND has a three-dimensional continuously adjustable function.

Modulator: speed instability is not greater than ± 1% AND the modulation frequency shall be in consistent with the frequency response characteristics of the detector.

Detector: the specific detectivity is not less than 10^8 cm • Hz $^{1/2}$ • W^{-1}, AND it shall at least have flat spectral response within the wavelength range of 1 μm ~ 25 μm.

Amplification system: the signal to noise ratio is greater than 20, the center frequency shall be in consistent with the modulation frequency, AND the non-linearity is not greater than ± 2%.

Millivolt meter: the accuracy is not less than 1.0.

Radiation thermometer: the accuracy is not less than ± 1%.

Note: The detection system consisting of a detector, an amplification system and a millivolt meter may also be replaced by an absolute radiant power meter which has an accuracy of not less than ± 2%.

18.1.1.3 Reference paint

Reference paint shall have the following properties:

a) Chemical stability, the reference paint which is coated over all kinds of heater surfaces within the range of the test temperature shall have no chemical change;

b) When the thickness is not less than 0.2 mm, the reference paint is opaque for 1 μm ~ 25 μm infrared radiation;

c) The average temperature change rate of the normal total emissivity in the test temperature range is less than 0.03 × 10^{-2} /K;

d) The normal total emissivity is greater than 0.8, AND the spectral radiation characteristic is approximate to the gray body;

e) The normal total emissivity data of the specified reference paint in the test temperature range has an accuracy of not less than ± 3%.

18.1.2 Measurement method

18.1.2.1 APPLY the rated working voltage to the sample under measurement. After the temperature is stabilized, USE the radiation thermometer to measure the surface temperature distribution at the sample surface, DETERMINE the working temperature of such temperature areas as the center part, CUT off the power supply; COOL it to room temperature.

18.1.2.2 FIX the sample onto the sample rack; ADJUST the optical system to make it comply with the following requirements:

a) The detector photosensitive surface and the modulation surface as well as the light bar plane and the sample radiant surface are parallel and coaxial;

b) The field angle of the effective beam defining light bar onto the detector is not more than 5.7°;

c) The area to be measured of the sample as determined by the effective beam defining light bar is located in the isothermal zone AND smaller than the isothermal area.

18.1.2.3 WELD or ATTACH the thermocouple of the temperature controller close to the surface to be measured (in the isothermal zone). USE the temperature controller to control the surface temperature to be measured at its working temperature. After the temperature is stabilized, MEASURE the differential signal voltage U_s between the sample as output from the amplification system and the modulation plate.

18.1.2.4 TURN off the temperature controller; after the sample is cooled to room temperature, uniformly COAT the reference paint in the isothermal area, with the coating thickness of 0.2 mm; after the coating is stable, MEASURE the differential signal voltage U_t between the reference paint as output from the amplification system and the modulation plate.

18.1.2.5 REMOVE the sample; MEASURE the differential signal voltage U_w between the background as output from the amplification system and the modulation plate.

18.1.2.6 USE the radiation thermometer to measure the apparent working temperature T_r of the isothermal zone.

18.1.3 Calculation of measurement results

microcomputer, and a plotter, AND the system accuracy shall not bet less than ± 2%.

Note 2: The part 6 ~ 10 in Figure 11 may also be substituted by the Fourier transform infrared spectroscopy.

19.1.2 Reference paint

The reference paint shall have the same properties and accuracy as that specified in 18.1.1.3.

19.2 Measurement methods

19.2.1 Same as 18.1.2.1.

19.2.2 FIX the sample onto the sample rack; ADJUST the optical system to make it reach to the following requirements:

a) It is same as the item a) of 18.1.2.2.

b) The area to be measured of the sample as determined by the optical system is subjected to “point source” approximation as relative to the detector; AND this area is located within the isothermal region AND less than the isothermal area.

19.2.3 WELD or ATTACH the thermocouple of the temperature controller close to the surface to be tested (in the isothermal zone). USE the temperature controller to control the temperature of the surface to be measured at the working temperature. After the temperature is stable, TURN on the monochromator scanning device, so that it can make continuous scanning within the wavelength range of 0.38 μm ~ 25 μm; meanwhile SYNCHRONIZE the recorder; MEASURE the relation curve between the differential spectral signal voltage $U_{S\lambda}$ of the sample as output from the amplification system and the modulation plate changing with the wavelength.

19.2.4 TURN off the temperature controller; after the sample is cooled to room temperature; uniformly COAT the reference paint in the isothermal area, with the coating thickness in 0.2 mm AND the coating method same as that used for the original measurement method of the emissivity data. Then TURN on the temperature controller (set the temperature same as that in 19.2.3). After the temperature is stable, FOLLOW the method of 19.2.3 to measure the relation curve between the differential spectral signal voltage $U_{t\lambda}$ of the reference paint as output from the amplification system and the modulation plate changing with the wavelength.

19.2.5 REMOVE the sample, MEASURE the relation curve between the differential spectral signal voltage $U_{w\lambda}$ of the background as output from the amplification system and the modulation plate changing with the wavelength (method same as that of 19.2.3).

Standard blackbody, the working temperature range is compatible with the radiation spectrum distribution of the measured sample, AND the temperature control accuracy is better than 1%.

20.2 Measurement method

20.2.1 SET the working temperature T_b of the black body at the value which is basically closing to the maximum temperature of the measured sample.

20.2.2 APPLY the rated working voltage to the heater; ENERGIZE to make its temperature rise to the stable temperature.

20.2.3 Under the same optical conditions, respectively MEASURE the relative radiant energy spectrum U_λ (T_b) of the blackbody AND the relative radiant energy spectrum U_λ (T) at the center of the sample.

20.3 Calculation of measurement results

20.3.1 USE the formula (11) to calculate the spectral radiant exitance M_λ (T):

$$M_\lambda(T) = \frac{U_\lambda(T)}{U_\lambda(T_b)} M_\lambda(T_b) \qquad \cdots\cdots (11)$$

Where:

M_λ (T) - The spectral radiant exitance of the sample, in watts per square centimeter micron [W/(cm^2 • μm)];

M_λ (T_b) - The spectral radiant exitance of the blackbody (given by the Planck formula), in the unit of watts per square centimeter [W/(cm^2 • μm)];

M_λ (T) - The relative radiant spectrum of the sample (the signal voltage output from the measuring system), in millivolts (mV);

M_λ (T_b) - The relative radiant spectrum of the blackbody (the signal voltage output from the measuring system), in millivolts (mV).

20.3.2 USE the equation (12) to calculate the effective radiant energy ratio R_e of the sample:

$$R_e = \frac{\int_{\lambda_1}^{\lambda_2} M_\lambda(T)\,d\lambda}{\int_{1}^{25} M_\lambda(T)\,d\lambda} \qquad \cdots\cdots (12)$$

Where $\lambda_1 \sim \lambda_2$ is the wavelength range corresponding to the total radiation flux of the sample.

b) Conventional life test method

At rated voltage, MAKE it continuously energized for n h.

Note: n is a natural number.

After the end of the test, if the final value of the electric heat radiation conversion efficiency of the heater to be measured is not less than 90% of the initial value and no damage occurs, it is determined that the life of the heater is not lower than n h.

23 Test method of vibration of heater

23.1 Test equipment

Vibration test bench: its characteristics shall comply with the relevant provisions in 4.1 of GB 2423.10-2008.

23.2 Test method

23.2.1 DETERMINE the following values in accordance with the vibration rating parameters as specified in the relevant product standards:

a) Frequency range;

b) Amplitude value;

c) Test duration.

23.2.2 Initial detection

UNPACK the heater to be tested; in accordance with the relevant product standards, CONDUCT appearance inspection and electrical performance test against the heater. After finishing the initial test, PACK the heater in accordance with the relevant product standards.

23.2.3 CONDUCT vibration test against the packaged heaters.

23.2.4 Final testing

UNPACK the sample which had been subjected to vibration test; and CONDUCT appearance inspection and electrical performance testing in accordance with the provisions of the relevant product standards.

24 Test method of mechanical strength of heater

It is applicable to the non-metallic matrix heaters.

24.1 Test equipment

26.2 Test methods

CONDUCT test in accordance with the relevant provisions of GB/T 8808-1988, and FOLLOW the requirements of relevant product standards to check whether it is qualified.

27 Test method of flame retardancy of heater

It is applicable to radiant electric film products.

FOLLOW the requirements of 30.102 in GB/T 4706.8-2003 to conduct test and assessment.

28 Test method of low temperature storage of heater

It is applicable to flexible radiation electric film AND flexible plane form radiation heating products.

28.1 Test equipment

Low temperature test chamber: the accuracy is better than ± 1 °C, the temperature fluctuation is ± 0.5 °C, AND the temperature uniformity ≤ 2 °C.

28.2 Test methods

In accordance with the requirements of relevant product standards, SET the low temperature test chamber at the designated test temperature. PLACE the sample in the low temperature test chamber; after storing it for a designated period, TAKE it out and LET it recover at room temperature for 1 h; TEST its input power, surface temperature, electrical strength, and appearance, AND assess whether they comply with the requirements of the relevant product standards.

29 Test method of overload capacity of heater

29.1 Test equipment

Three-phase voltage regulator, the power meter having an accuracy of not less than level 0.5, AND the voltmeter having an accuracy of not less than level 0.5.

29.2 Test methods

CONNECT the heater to the power supply; meanwhile ADJUST the voltage to make the output power reach to the specified value; under the adequate heating conditions of the heater, ENERGIZE it for 1 h; CUT off the power and COOL it for 0.5 h to make the temperature reach to room temperature (forced cooling may be used if necessary). AND the number of cycles of power on and off is 30.

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