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NATIONAL METROLOGY VERIFICATION REGULATION OF THE PEOPLE'S REPUBLIC OF CHINA

JJG 229-2010

Industry Platinum and Copper Resistance

Thermometers

工业铂、铜热电阻

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Industry Platinum and Copper Resistance Thermometers

1 Scope

This Regulation is applicable to the initial verification, subsequent verification and in-use inspection of industry platinum thermal resistance in the whole or part temperature range of $-200^{\circ}\text{C}\sim+850^{\circ}\text{C}$ and with the nominal value α of temperature coefficient of $3.851\times 10^{-3}^{\circ}\text{C}^{-1}$; as well as the industry copper thermal resistance (hereinafter referred to as thermal resistance) in the whole or part temperature range of $-200^{\circ}\text{C}\sim+850^{\circ}\text{C}$ and with the nominal value α of temperature coefficient of $4.280\times 10^{-3}^{\circ}\text{C}^{-1}$.

2 References

The following references are cited in this Regulation:

IEC 60751 (2008) Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

JB/T 8623-1997 Technical Specification and Reference Table for Industrial Copper Thermal Resistance

When citing, pay attention to using the currently valid version of the above cited references.

3 Terms and Definitions

3.1 Resistance thermometer

A temperature measuring instrument composed of one or more temperature-sensing resistance elements with lead wires, protective tubes and wiring terminals.

3.2 Nominal resistance R_0

The expected resistance value of the thermal resistance (or temperature sensing element) at 0°C . The resistance values are usually: 10Ω , 50Ω , 100Ω , 500Ω , 1000Ω , which are declared by the manufacturer and marked on the thermal resistance. Temperature sensing element is often characterized by its nominal resistance value. For example, a Pt100 temperature sensing element has a nominal resistance value of

6 General Technical Requirements

6.1 Appearance

6.1.1 All parts of the thermal resistance shall be assembled correctly, reliably, and without missing parts; the outer coating shall be firm; the protective tube shall be intact; and there shall be no dents, scratches and significant corrosion;

6.1.2 The temperature sensing element must not be broken, and there must be no obvious bending;

6.1.3 According to the needs of the measurement circuit, the thermal resistance can have a two-, three- or four-wire connection mode; thereof, the Level-A and Level-AA thermal resistance must be three-wire or four-wire connection.

6.1.4 Each thermal resistance shall have at least the following markings on its protective sleeve or on its attached label:

- Type code;
- Nominal resistance value R_0 ;
- Effective temperature range;
- Number of temperature sensing elements;
- Tolerance level;
- Manufacturer's name or trademark;
- Production year and month.

NOTE 1: If symbols are used to express such information, their markings shall be easy to identify.

NOTE 2: The verification markings shall be placed on the protective sleeve or on the attached label of the thermal resistance.

6.2 Insulation resistance

The insulation resistance between the temperature sensing element and the housing, and each temperature sensing element shall meet the following requirements:

- a) For the insulation resistance at room temperature, when the resistance thermometer is in an environment with a temperature of 15°C ~35°C and a relative humidity of 45%~85%, the insulation resistance shall be no less than 100MΩ;

(a)

(b)

Figure 1 – Wiring Method for Three-Wire Thermal resistance

The electrical measuring instrument can select a bridge or digital multimeter that meets the requirements of measurement accuracy. In order to weaken the influence of thermoelectric potential, the current should be commutated when measuring resistance with a digital multimeter; and the average value shall be taken. Considering the factors that change the temperature of the thermostat bath with time, the method of alternately measuring the thermal resistance and the standard platinum resistance shall be used in the shortest possible time; and the number of alternately repeating shall be no less than 4 times (including current commutation), and taking the average value as the measurement result.

7.3.4.3 Verification of R_0

Measure the resistance value of the thermal resistance in a freezing point tank (or a thermostat tank with 0°C , the deviation does not exceed $\pm 0.2^\circ\text{C}$), and compare it with the temperature of the freezing point tank measured by a standard measuring device, and calculate the deviation Δt_0 at 0°C .

For the thermal resistance with protective tube detachable, in order to shorten the thermal equilibrium time, the temperature sensing element and the lead wire can be taken out from the liner tube and the protective tube; and placed in a glass test tube with an inner diameter slightly larger than the diameter of the temperature sensing element. Tighten the plug with absorbent cotton, insert it into the freezing point tank; and be surrounded by a layer of ice-water mixture no less than 30mm. The ice-water mixture must be pressed tightly to eliminate air bubbles before measurement, and this state must be maintained throughout the measurement. For the thermal resistance with protective tube undetachable, there must be sufficient thermal equilibrium time during verification, and the reading can be read after the measurement data is stable.

If a 0°C thermostat bath is used, the thermal resistance shall have sufficient insertion depth to minimize heat loss.

To verify the thermal resistance above Level-AA, in order to reduce the measurement uncertainty, it is recommended to measure in a water triple point cell, and obtain the R_0 value through calculation.

Calculation of R_0 (method procedures):

- a) The value Δt_i^* that the freezing point tank deviates from 0°C is measured by a standard platinum resistance thermometer.

Its value is calculated according to Formula (1):

$$s_p = \sqrt{\frac{1}{3} \sum_{i=1}^3 s_i^2} = 4.34 \times 10^{-3} \Omega$$

The actual measurement shall take the average value of the 4 measurement

values as the measurement result; thus, $u(R_{h1}) = \frac{s_p}{\sqrt{4}} = 2.17 \times 10^{-3} \Omega$

Convert into temperature: $u(\Delta t_{h1}) = \frac{u(R_{h1})}{(dR/dt)_{t=0}} = \frac{2.17 \times 10^{-4}}{0.37928} = 0.57 \text{ mK}, \nu_1 = 69$

E.5.2 The standard uncertainty $u(\Delta t_{i2})$ and $u(\Delta t_{h2})$ introduced by the temperature difference between the plugholes – Type-B uncertainty

The temperature difference between the plugholes of freezing point tank is very small and can be ignored.

The uniformity of the temperature field between the plugholes of water boiling point tank does not exceed 0.01°C ; during the verification process, the temperature fluctuation does not exceed $\pm 0.02^\circ\text{C}/10\text{min}$. Due to the difference between the standard and the time constant under test, it is estimated that there shall be a hysteresis of no more than 0.01°C . All obey uniform distribution, $k=\sqrt{3}$. therefore:

$$u(\Delta t_{h2}) = \frac{0.01\sqrt{2}}{\sqrt{3}} = 8.16 \text{ mK}$$

The estimated relative uncertainty is 20%, and its degree of freedom $\nu_2 = 12$.

E.5.3 Standard uncertainty $u(\Delta t_{i3})$ and $u(\Delta t_{h3})$ introduced by electrical measuring equipment – Type-B uncertainty

The measurement error of the thermal resistance measuring instrument is the main source of uncertainty. The uncertainty caused by the stray potential of the four-terminal change-over switch is relatively small (converted into resistance, no more than $\pm 1\text{m}\Omega$) and can be ignored.

When verifying at 0°C , the half-width of the uncertainty interval of the thermal resistance measuring instrument is $100\Omega \times 0.01\% + 0.001 = 0.0110\Omega$, which can be regarded as uniformly distributed in the interval, $k=\sqrt{3}$. Then:

$$u(R_{i3}) = \frac{0.0110}{\sqrt{3}} = 6.35 \times 10^{-3} \Omega$$

Convert into temperature: $u(\Delta t_{i3}) = \frac{6.35 \times 10^{-3}}{0.39083} = 16.25 \text{ mK}$

When verifying at 100°C , the half-width of the uncertainty interval of the thermal

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