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# Calibration specification of temperature data acquisition instruments

温度数据采集仪校准规范

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# Calibration specification of temperature data acquisition instruments

## 1 Scope

This Specification is applicable to the calibration of temperature data acquisition instruments (hereinafter referred to as acquisition instruments), which have built-in sensors AND a measurement range of (-50 ~ +150) °C, as well as outlay sensors AND a measurement range of (-80 ~ +500) °C.

## 2 Normative references

This Specification cites the following documents:

JJG 617-1996 Verification regulation of digital temperature indicators and controllers

JJF 1001-2011 General terms in metrology and their definitions

JJF 1007-2007 Temperature metrological terms and their definitions

JJF 1030-2010 Measurement and test norm of thermostatic bath's metrological characteristics

JJF 1101-2003 Calibration specification for the equipment of the environmental testing for temperature and humidity

JJF 1171-2007 Calibration specification for temperature itinerant detecting instrument

For dated references, only the dated version applies to this Specification; for undated references, the latest edition (including all amendments) applies to this Specification.

## 3 Terminology

The terms and definitions, as defined in JJF 1001-2011 and JJF 1007-2007, as well as the following terms and definitions, apply to this Specification.

### 3.1 Temperature data acquisition instrument

A temperature measuring instrument, which can be directly placed in the measured environment for measurement; has the functions of automatically collecting the

### 5.4 ON-OFF mode

The acquisition instrument shall be able to set how it turns on and off. The turn-on mode is fixed OR optional, such as immediate turn-on, time-fixed turn-on, time-delayed turn-on, manual start, etc. The turn-off mode is fixed OR optional, such as turn-off are full storage, first-in first-out, turn-off by numbers, manual turn-off, etc.

### 5.5 Over-temperature alarm

For an acquisition instrument, which has an over-temperature alarm function, the over-temperature alarm shall be normal.

### 5.6 Appearance

**5.6.1** For the acquisition instrument with local indication, its digital indication shall be clear; there shall be no digital flickering, overlapping characters, garbled characters, missing strokes; the indication of decimal point shall be correct.

**5.6.2** The acquisition instrument, which can be used by putting into liquid, shall be sealed without damage.

Note: All the above technical indicators are not applicable to eligibility judgment, only for reference.

## 6 Calibration conditions

### 6.1 Environmental conditions

a) Ambient temperature: (20 ± 5) °C;

b) Relative humidity: Not more than 85%;

c) When the electrical measuring instrument has other requirements for environmental conditions, it shall meet its specified requirements.

Note: If the above conditions cannot be met, the resulting uncertainty shall be considered.

### 6.2 Power supply conditions

The power supply shall meet the normal working requirements of the acquisition instrument, measurement standard, constant temperature equipment under verification.

sensitive element immersed in the uniform temperature zone of the constant temperature bath, meanwhile the influence of the ambient temperature is negligible, it shall follow the requirements in 6.6.5 of JJF 1171-2007, to place the temperature sensor in the constant temperature bath; the data acquisition part is placed outside the constant temperature bath;

b) If the temperature sensor of the acquisition instrument is outlay type AND the length of the sensor cable or the insertion rod is not enough to make the temperature sensitive element immersed in the uniform temperature zone of the constant temperature bath; OR although it can be submerged enough, the ambient temperature cannot be ignored, due to the excellent thermal conductivity of the immersion rod; OR when the temperature sensor is built-in and the data acquisition part is not sealed, THEN, it shall be placed in the uniform temperature area of the incubator, as a whole;

Note: In this case, the calibration temperature range of the outlay sensor acquisition instrument is the same as that of the built-in sensor acquisition instrument.

c) For an integrally sealed acquisition instrument, the whole can be put into a metal mesh bag AND immersed in a uniform temperature zone below 200 mm, from the liquid medium level of the thermostat; OR the whole can be placed in the uniform temperature zone of the thermostat.

**7.3.5 Communication connection**

For the acquisition instrument of wireless communication, after the installation of the acquisition instrument is completed, it may turn on the communication receiver and the PC, to establish the real-time communication connection, between the acquisition instrument and the communication receiver and the PC.

**7.3.6 Selection of calibration point**

The calibration points shall be evenly distributed on the integral point of the entire measurement range; in principle, it shall include the zero point, the upper limit value, the lower limit value; there shall be no less than 5 points.

When the user has requirements, the calibration point can be selected, according to the user's requirements.

**7.3.7 Use of measurement standards**

When using a standard mercury thermometer as the measurement standard, a reading telescope shall be used to read its indication. When using a standard platinum resistance thermometer as the measurement standard, its working current shall not be greater than 1 mA; the insertion depth shall not be less than 250 mm.

When using an incubator as a constant temperature source, the standard thermometer

shall be inserted vertically. At the same time, in order to reduce or eliminate the heat exchange between the insertion hole of the incubator and the outside world, it shall use cotton or other insulating materials, to plug the gap between the standard thermometer and the insertion hole.

**7.3.8 Calibration method**

Keep the temperature of the incubator constant, at each temperature point to be calibrated; the temperature deviation from the calibration point shall not exceed ±0.2 °C (subject to the indication value of measurement standard). When the temperature of the incubator is constant for 20 minutes OR the temperature of the incubator is constant for more than 40 minutes, it shall calculate the reading time, according to the set turn-on mode and recording interval of the acquisition instrument. At the time when the acquisition instrument records the data, read and record the indication value of the measurement standard and the timer; meanwhile, take 4 readings continuously, at the set recording interval of the acquisition instrument.

After completing the measurement of the last calibration temperature point, take out the acquisition instrument or temperature sensor; when its temperature reaches near the ambient temperature, connect to the PC, according to the operation instructions of the acquisition instrument; read, print or display the temperature measurement data and corresponding time values, which are collected and recorded by the acquisition instrument, through the PC.

For the acquisition instrument of wireless signal transmission, after establishing the real-time communication connection, according to the method of 7.3.5, it can read the measurement standard and the real-time display value of the PC, at the same time. Read the real-time indication value of the measurement standard and the PC, respectively, in the order of "standard → calibrated → calibrated → standard". The above sequence is one reading cycle. Two cycles of reading shall be performed.

For the acquisition instrument with local indication function, it reads the local indication value of the measurement standard and the acquisition instrument, respectively, according to the reading method of calibrating the wireless signal transmission acquisition instrument.

For the acquisition instrument without sensor, according to the calibration circuit specified in JJG 617-1996, input the analog electrical signal corresponding to each calibration point to the acquisition instrument, using the method of inputting the nominal electric quantity value; read the measured value according to the above method.

For multi-channel acquisition instruments, the measurement error of each channel shall be calibrated separately.

For an acquisition instrument, whose maximum allowable error does not exceed ±0.1 °C, when a standard platinum resistance thermometer and electrical measuring

error of the acquisition instrument does not exceed ±0.1 °C, $R_{tp}$ shall be the measured value;

$W_{t_n}$, $\left(\frac{dW_t}{dt}\right)_{t_n}$ - The resistance ratio and the rate of change of the resistance ratio, as corresponding to the temperature $t_n$, which is given by the standard platinum resistance thermometer's scale table.

c) For multi-channel acquisition instruments, the measurement error of each channel shall be calculated separately.

d) Round off the data, in accordance with the rounding-off principle of data processing. The last digit of the measurement result Δt shall be aligned with the last digit of its measurement uncertainty.

# 8 Expression of calibration results

The calibration results shall be reflected on the calibration certificate. The calibration certificate shall include at least the following information:

a) Title: "Calibration certificate";

b) Laboratory name and address;

c) The location where the calibration is performed (if different from the laboratory's address);

d) The unique identification (such as number) of the certificate, the identification of each page and the total number of pages;

e) The name and address of the customer;

f) The description and clear identification of the calibrated subject;

g) The date of the calibration; if relevant to the validity and application of the calibration results, the date of receipt of the subject to be calibrated;

h) If relevant to the application of the validity of the calibration results, the sampling procedures for the samples to be calibrated shall be explained;

i) Identification of the technical specification on which the calibration is based, including name and code;

j) Traceability and validity statement of the measurement standards, which are used in this calibration;

k) The description of the calibration environment;

# Appendix C

## Example for evaluation of measurement uncertainty (1)

### C.1 Measured object

Taking the acquisition instrument, which has a resolution of 0.1 °C, as an example, use the standard mercury thermometer as the measurement standard, use the constant temperature bath as the supporting equipment for calibration, to evaluate the uncertainty of the measurement error of the acquisition instrument, at the calibration point of 20.0 °C.

### C.2 Assessment model

### C.2.1 Mathematical model

The mathematical model of the measurement error of the acquisition instrument is:

$$\Delta t = \bar{t}_i - (\bar{t}_0 + t_d) = \delta t_i - t_d$$

Where:

Δt - At each calibration point, the measurement error of the calibrated acquisition instrument, °C;

$\bar{t}_i$ - At each calibration point, the average value of the indication value of the calibrated acquisition instrument, °C;

$\bar{t}_0$ - At each calibration point, the average value of the measured value of the standard mercury thermometer, °C;

$t_d$ - The correction value of the indication value of the standard mercury thermometer, at each calibration point, °C;

$\delta t_i$ - At each calibration point, the difference between the average value of the measured value of the calibrated acquisition instrument and the standard mercury thermometer, °C.

### C.2.2 Sensitivity factor

Sensitivity factor for $\delta t_i$:

$$c_1 = \partial \Delta t / \partial \delta t_i = 1$$

Sensitivity factor for $t_d$:

$$c_2 = \partial \Delta t / \partial t_d = -1$$

**C.2.3 Variance**

The variance formula is

$$u_c^2(\Delta t) = c_1^2 u^2(\delta t_i) + c_2^2 u^2(t_d)$$

**C.3 Sources of standard uncertainty**

**C.3.1** Standard uncertainty $u(\delta t_i)$ due to input quantity $\delta t_i$

The standard uncertainty $u(\delta t_i)$, which is caused by the input quantity $\delta t_i$, consists of the following 5 components:

a) The standard uncertainty $u(\delta t_{i1})$, which is introduced by the measurement repeatability of the calibrated acquisition instrument and standard mercury thermometer;

b) The standard uncertainty $u(\delta t_{i2})$, which is introduced by the inhomogeneity of the temperature field of the constant temperature bath;

c) The standard uncertainty $u(\delta t_{i3})$, which is introduced by the resolution of the calibrated acquisition instrument;

d) The standard uncertainty $u(\delta t_{i4})$, which is introduced by the non-vertical insertion of the standard mercury thermometer;

e) Standard uncertainty $u(\delta t_{i5})$, which is introduced by standard mercury thermometer's estimation.

**C.3.2** Standard uncertainty $u(t_d)$ due to input quantity $t_d$

The standard uncertainty $u(t_d)$, which is caused by the input quantity $t_d$, is mainly introduced by the quantity transfer of the standard mercury thermometer.

**C.4 Evaluation of standard uncertainty**

**C.4.1** Evaluation of $u(\delta t_i)$

**C.4.1.1** Evaluation of $u(\delta t_{i1})$

The temperature fluctuation of the constant temperature bath, the short-term instability of the tested acquisition instrument and the standard mercury thermometer, etc., will all lead to the non-repetition of the difference, between the indication value of the tested acquisition instrument and the standard mercury thermometer. The category A evaluation method is adopted.

# Appendix D

## Example for evaluation of measurement uncertainty (2)

### D.1 Measured object

Taking the acquisition instrument, which has a resolution of 0.01 °C, as an example, the level-2 standard platinum resistance thermometer and 1590 thermometer bridge are used, as the measurement standards, for calibration. Evaluate the uncertainty of the measurement error of the acquisition instrument, at the calibration point of 50.0 °C.

### D.2 Assessment model

**D.2.1** Mathematical model

The mathematical model of the measurement error of the acquisition instrument is:

$$\Delta t = \bar{t}_i - \bar{t}_0$$

Where:

Δt - At each calibration point, the measurement error of the calibrated acquisition instrument, °C;

$\bar{t}_i$ - At each calibration point, the average value of the indication value of the calibrated acquisition instrument, °C;

$\bar{t}_0$ - At each calibration point, the average value of the measured value of the standard thermometer, °C.

**D.2.2** Sensitivity factor

The sensitivity factor of $\bar{t}_i$:

$$c_1 = \partial \Delta t / \partial \bar{t}_i = 1$$

Sensitivity factor of $\bar{t}_0$:

$$c_2 = \partial \Delta t / \partial \bar{t}_0 = -1$$

**D.2.3** Variance

The variance formula is

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