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Calibration specification for capacitive digital scale units

容栅数显标尺校准规范

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Calibration specification for capacitive digital scale units

1 Scope

This Specification is applicable to the calibration of various specifications of capacitive digital scale units, which have a resolution of 0.005 mm, 0.01 mm, and a measurement range of (0 ~ 2000) mm.

2 Normative references

This Specification refers to the following documents:

JJF 1001-1998 General terms in metrology and their definitions

JJF 1059-1999 Evaluation and expression of uncertainty in measurement

JJF 1094-2002 Evaluation of the characteristics of measuring instruments

GB/T 22518-2008 Capacitive digital scale units

When using this Specification, attention shall be paid to using the current valid versions of the above referenced documents.

3 Overview

The capacitive digital scale consists of a capacitive main scale and a running frame equipped with a capacitive digital display unit. It is a measuring instrument used to measure linear displacement. The schematic diagram of its appearance structure is shown in Figures 1 and 2.

each measuring point, within the range of the capacitive digital scale unit, is taken as the indication error measurement result of the capacitive digital scale unit.

6.1.2 Gauge block measurement method

The indication error of the non-enclosed capacitive digital scale unit, which has an upper limit of no more than 1000 mm, can also be measured by using 5-division gauge blocks in conjunction with a measuring fixture (see Figure 4 or Figure 5). The anvil of the measuring fixture is fixed on the main scale; the measuring plate is fixed on the running frame mounting plate. The difference between the above two measuring fixtures is that the ball probe of the measuring plate is in different positions; either one of them can be selected. When measuring, first move the running frame to make the ball probe of the measuring plate contact the measuring anvil's measuring surface; the display screen reads "zero". Then move the running frame; place a gauge block of the corresponding size between the ball probe and the measuring anvil's measuring surface for contact measurement; read the indication value from the display screen. The difference between the indication value of the capacitive digital scale unit and the actual size of the gauge block at each measuring point is the indication error of the measuring point. The difference between the maximum and minimum indication errors of each measuring point, within the measuring range, is taken as the indication error measurement result of the capacitive digital scale unit. The selection of measuring points refers to the provisions of 6.1.1.

Note: The flatness and surface roughness of the measuring surface of the measuring anvil of the measuring fixture shall meet the requirements of the 5-division gauge block; when the measuring anvil is installed, the perpendicularity between the measuring surface of the measuring anvil and the guide surface of the capacitive digital scale is not greater than 10'.

When the upper limit of measurement is not greater than 400 mm, the capacitive digital scale unit generally adopts horizontal measurement. When the upper limit of measurement is greater than 400 mm and less than or equal to 1000 mm, vertical measurement can be adopted.

Appendix A

Uncertainty evaluation of the measurement result of the indication error of the capacitive digital scale unit

(Special measuring device measurement method)

A.1 Measurement method

According to this calibration Specification, the indication error of the capacitive digital scale unit, which has a resolution of 0.005 mm and a measurement upper limit of 300 mm, is measured using a special measuring device (in this example, a laser interferometer is used as a standard), to evaluate the uncertainty of the indication error measurement result.

A.2 Mathematical model

The mathematical model of the indication error of each measuring point is:

$$e = l - l_s \quad (\text{A. 1})$$

Where:

e - Indication error of the capacitive digital scale unit;

l - Indication of the capacitive digital scale unit (under 20 °C);

l_s - Indication of the laser interferometer (under 20 °C).

A.3 Variance and sensitivity coefficient

Variance:

$$u_c^2 = u^2(e) = c_1^2 \cdot u^2(l) + c_2^2 \cdot u^2(l_s) \quad (\text{A. 2})$$

Sensitivity coefficient:

$$c_1 = \partial e / \partial l = 1; \quad c_2 = \partial e / \partial l_s = -1$$

A.4 Standard uncertainties

A.4.1 Uncertainty $u(\Delta l)$ introduced by the variability (Δl) of the indication of the capacitive digital scale unit

The indication variability (Δl) obeys a uniform distribution and affects the calibration process twice. The standard uncertainty introduced is:

$$u(\Delta l) = \frac{\sqrt{2} \times (0.5 \times \Delta l)}{\sqrt{3}} = \frac{\sqrt{2} \times (0.5 \times 0.005 \text{ mm})}{\sqrt{3}} = 0.0022 \text{ mm}$$

Appendix B

Uncertainty evaluation of the indication error measurement result of the capacitive digital scale unit

(Gauge block measurement method)

B.1 Measurement method

According to this calibration Specification, 5-division blocks are used to measure the indication error of the capacitive digital scale unit, which has a resolution of 0.005 mm and a measurement upper limit of 300 mm; the uncertainty of the indication error measurement result is evaluated.

B.2 Mathematical model

The mathematical model of the indication error of each measuring point is formula (1). Considering the influence of the measurement uncertainty factor during measurement, formula (1) is transformed into:

$$e = l - l_s + L \cdot \bar{\alpha} \cdot \delta_t + L \cdot \Delta t \cdot \delta_a \quad (\text{B. 1})$$

Where:

e - Indication error of the capacitive digital scale unit;

l - Indication of the capacitive digital scale unit (under 20 °C);

l_s - Actual value of the size of 5-division gauge blocks (under 20 °C);

L - Nominal size of the calibration point;

$\bar{\alpha}$ - Average linear expansion coefficient of the capacitive digital scale unit and the gauge block;

δ_t - Temperature difference between the capacitive digital scale unit and the gauge block;

Δt - Difference between the average temperature of the capacitive digital scale unit and the gauge block to 20 °C;

δ_a - Difference in linear expansion coefficient between the capacitive digital scale unit and the gauge block.

B.3 Variance and sensitivity coefficient

Variance:

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