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NATIONAL STANDARD

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GB/T 15478-2015

Replacing 15478-1995

Test methods of the performances for pressure transducer/sensor

压力传感器性能试验方法

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Foreword

The standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This standard replaces GB/T 15478-1995 “Test methods of the performance for pressure transducer/sensor”. As compared with GB/T 15478-1995, the main changes of this standard are as follows:

-In 3.1.2 and 3.1.3, MODIFY the relative humidity to “30% ~ 85%”, and MODIFY the deviation range to “± 5%”;

-CANCEL the clause 3.2 dynamic conditions from the original standard;

- Respectively determine the indicators in 3.3.1b), 3.3.2 and 3.3.3 as 1/3, 1/5 and 1/5;

-In 5.3.2b), with respect to the output impedance, DIVIDE the sensor circuit into passive circuit and active circuit, with corresponding test methods;

-In 5.4.2.4, MODIFY the hysteresis definition to “Hysteresis is, at the same test point, the maximum absolute value of the output difference when the measured value increases and decreases”;

-In 5.4.2.5, MODIFY the repeatability definition to “Repeatability is the consistency between successive measurement results”;

-REMOVE the two indicators “zero drift” and “overload (overload)”from the static performance indicators, both of which are listed as independent items;

- CHANGE the “sensitivity stability” to “full scale output stability”;

-In 5.6.2b), MODIFY the “... 5 to 10 times the dynamic performance of the sensor.” to “... 5 times the dynamic performance of the sensor.”;

-In 5.9.2.1,CONDUCT detailed descriptions against the “temperature effect test”, making specific requirements; MODIFY the “thermal sensitivity drift” to “thermal full-scale output drift”; MODIFY the “thermal sensitivity lagging” to the “thermal full scale output lagging”; MODIFY the “conduct three measurement upper and lower calibration cycles” to the “conduct one measurement upper and lower calibration cycle (only one cycle is measured)”;

Test methods of the performances for pressure transducer/sensor

1 Scope

This standard specifies the test conditions, the general provisions of the test, the test items and the test methods, AND data calculation and processing for the performance of the pressure sensor (abbreviated as sensor).

This standard applies to pressure sensors (including absolute pressure sensor, differential pressure sensor, gauge pressure sensor AND negative pressure sensor).

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this Standard.

GB/T 2423.1-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test A: Cold;

GB/T 2423.2-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test B: Dry heat;

GB/T 2423.3-2006 Environmental testing for electric and electronic products - Part 2: Test methods - Test Cab: Damp heat steady state;

GB/T 2423.5-1995 Environmental testing for electric and electronic products - Part 2: Test methods - Test Ea and guidance: Shock;

GB/T 2423.10-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test Fc: Vibration (sinusoidal);

GB/T 2423.15-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test Ga and guidance: Acceleration steady;

GB/T 2423.17-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test Ka: Salt mist;

GB/T 2423.21-2008 Environmental testing for electric and electronic products - Part 2: Test methods - Test M: Low air pressure

GB/T 2423.24-2013 Environmental testing – Part 2: Test methods – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing;

GB/T 2423.25-2008 Environmental testing – Part 2: Test methods – Test Z/AM: Combined cold/low air pressure tests;

GB/T 2423.26-2008 Environmental testing – Part 2: Test methods – Test Z/AM: Combined dry heat/low air pressure tests;

GB/T 2423.27-2005 Environmental testing for electric and electronic products - Part 2: Test methods - Test Z/AMD: Combined sequential cold, low air pressure and damp heat test;

GB/T 2423.37-2006 Environmental testing for electric and electronic products - Part 2: Test methods - Test L: Dust and sand;

GB/T 8170-2008 Rules for rounding off for numerical values & expression and judgment of limiting values;

GJB 150.17A-2009 Military equipment laboratory environmental test methods - Part 17: Noise test.

3 Test conditions

3.1 Environmental conditions

3.1.1 Reference atmospheric conditions

The reference performance test of the sensor shall be conducted at the following reference atmospheric conditions:

Temperature: 18 °C ~ 22 °C;

Relative humidity: 60% ~ 70%;

Atmospheric pressure: 86kPa ~ 106kPa.

3.1.2 General test atmospheric conditions

If it is impossible of unnecessary for the sensor to be subjected to the test under the reference atmospheric conditions, it is recommended to use the following atmospheric conditions:

b) Details of the inspection;

c) Magnification(if specified);

d) Specified values and judgment criteria of the characteristic parameters;

e) Differences from the test methods of this standard.

5.2 Inspection of dimensions and weights

5.2.1 Inspection items

The inspection items include:

a) Overall dimensions;

b) Mechanical interface form and dimensions;

c) Weight.

5.2.2 Inspection methods

It shall use the below mentioned appropriate gauges to conduct dimension and weight inspection against the sensors:

a) Calipers, micrometers and dial indicators;

b) Standard gauge, standard meter;

c) Projectors with appropriate linear magnification;

d) Measurement microscope, triple coordinates measurement instrument or the measurement instrument of equivalent accuracy;

e) Balance.

5.2.3 Provisions on inspection details

The details of the inspection of the tested sensor shall be specified by the detailed specification of the sensor. These include:

a) Characteristic parameters of inspection;

b) Details of the standard gauge and standard meter (if applicable);

c) Measurement instrument model and magnification;

d) Specified values and judgment criteria of the characteristic parameters;

Y_{KL} – Output voltage of sensor when its output end is under open circuit and no load, in the unit of volts (V);

Y_{FL} – Output voltage of sensor when its output end is connected with a 10kΩ load resistance, in the unit of volts (V).

c) Load impedance:

When the input end of the tested sensor is applied with excitation power supply AND the output end of the tested sensor is connected with variable resistor, gradually REDUCE the resistance value of the variable resistor, until the output value of the sensor exceeds the value as specified in the detailed specifications, then the resistance value as indicated by the variable resistor is the load impedance of the sensor.

d) Insulation resistance:

When the tested sensor is not applied with the excitation power supply, USE the insulation resistance tester OR corresponding instrument to apply a specified DC voltage to the sensor, and MEASURE the insulation resistance between the sensor's lead-out end and the enclosure (including the power outlet and plug, as well as the lead wire).

e) Dielectric strength:

When the tested sensor is not applied with the excitation power supply, USE the dielectric strength tester OR corresponding instrument to apply a specified 50 Hz AC voltage between the sensor's lead-out end and the enclosure, AND there shall be no breakdown or arcing within the specified time.

5.3.3 Provisions on test details

The test details of the tested sensor shall be specified by the detailed specification of the sensor. These include:

a) Characteristic parameters of test;

b) Instrument and equipment used for the test;

c) Environmental conditions for the test;

d) Specified values and judgment criteria of the characteristic parameters;

e) Differences from the test methods of this standard.

5.4 Static performance test

The dynamic performance parameters of the sensor shall be tested using one of the following methods:

a) Transient excitation method:

CONNECT the sensor to the shock tube or the quick-opening valve; as for the negative pressure sensor, it is allowed to use the negative step pressure signal which is generated by the bursting diaphragm generator; AND the rise time of the aforementioned step pressure shall be 1/3 or smaller of the sensor rise time.

When the excitation device generates a step pressure signal, USE the transient recorder to record the response waveform of the sensor; then CONDUCT analysis against it, in order to determine each parameter of the dynamic characteristics.

b) Sinusoidal excitation method:

USE the sinusoidal pressure generator to directly measure the frequency response of the sensor. If the resonant frequency of the sensor itself is within the frequency range of the sinusoidal pressure generator, it can also obtain the resonant frequency, damping ratio and response time of the sensor.

When using the sinusoidal excitation method, it shall install the standard sensor on the sinusoidal pressure generator, for which the dynamic performance indictor shall be higher than 5 times of the dynamic performance of the tested sensor.

Through the aforementioned test method, it can determine the following dynamic characteristic parameters.

5.8.3 Dynamic performance parameters

5.8.3.1 Frequency response

Within the specified frequency range, as for the measured sinusoidal change as applied on the sensor, the ratio between the output and the measured amplitude as well as the change of the difference between the output and the measured value with frequency is the frequency response, which is expressed as from zero to ____ (Hz), the amplitude error is not greater than ____ %; AND the phase deviation is not greater than ____. As for the piezoelectric dynamic pressure sensors, it is expressed as from ____ (Hz) which is near zero to ____ (Hz), the amplitude error is not greater than ____ %; AND the phase deviation is not greater than ____.

The temperature effect test of the sensor shall be conducted in accordance with the test Ab of GB/T 2423.1-2008 AND the test Bb of GB/T 2423.2-2008.

During the test, firstly RECORD the ambient temperature; under the general atmospheric test conditions, CONDUCT 3 times of upper limit and lower limit calibration cycles, in order to measure its zero output mean value AND full scale output mean value under general atmospheric test conditions; it is also allowed to place the sensor into the high and low temperature test chamber in which the temperature is consistent with the ambient temperature for the test. Then, PLACE the sensor in a suitable high and low temperature chamber; at a certain temperature (at least the upper limit and lower limit of the working temperature range) after a specified period of time to reach sufficient heat stability, RECORD the temperature value and MEASURE one upper limit and lower limit calibration cycle (only measuring one cycle); RETURN back to the same temperature before starting the test; RE-MEASURE the zero output value and the full scale output value (allowing for only one test). Finally, USE the equation (A.35) ~ (A.40) of the Appendix A to calculate the thermal zero drift (α), thermal full scale output drift (β), thermal zero lag (α_H), and thermal full scale output hysteresis (β_H). The test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.2 Vibration effect test

The vibration effect test of the sensor shall be conducted in accordance with GB/T 2423.10-2008.

During the test, MOUNT the sensor on a vibration test rig; based on the specified frequency and amplitude (or acceleration), MAKE it vibrate along the specified direction. RECORD the zero output signal of the sensor before and during the vibration, and USE the equation (A.41) to calculate the effect of vibration onto the zero point. After the vibration test, in accordance with 5.4, CONDUCT the static performance test, AND the test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.3 Impact effect test

The impact test of the sensor shall be conducted in accordance with GB/T 2423.5-1995.

MOUNT the sensor on an impact test rig; based on the specified acceleration and axial direction, APPLY impact; after reaching to the specified impact times, in accordance with 5.4, CONDUCT the static performance test, AND the test results shall comply with the requirements as specified in the detailed specifications of the sensor.

PLACE the tested sensor in the vacuum box; CONNECT the test recording instrument. When the vacuum reaches the specified value and remains constant, RECORD the zero output of the sensor. In this state, MAINTAIN a specified time; then RECORD the zero output again; AND error as caused by the zero output change shall comply with the requirements as specified in the detailed specifications of the sensor.

b) Unidirectional and bidirectional differential pressure sensors:

CONNECT the “high” pressure end and “low” pressure end of the sensor; ASSEMBLE with the standard barometer; through a vacuum valve, CONNECT with the vacuum pump to form a system; EMPTY the entire system to the specified pressure; CLOSE the vacuum valve to cut off the vacuum source. Within the specified time, OBSERVE the pressure indication of the standard barometer, AND its change shall not exceed the specified value (Pa). It is also allowed to change the vacuum pump into one positive pressure source, in order to pressurize the “high” pressure chamber and the “low” pressure chamber to the specified value; and SOAK the sensor into the liquid medium (such as water); within the specified time, there shall be no visible bubbles escape.

c) Vacuum helium mass spectrometry leak detection:

CONNECT the sensor pressure chamber and the helium mass spectrometer leak detector, in order to directly detect the leakage rate of the sensor pressure chamber, the value of which shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.8 Salt mist effect test

The salt mist effect test of the sensor shall be conducted in accordance with the provisions of GB/T 2423.17-2008.

After this test, it is not allowed for any electrical test. After the test, USE the distilled water to wash it clean; DRY it; CONDUCT sensor appearance inspection (pay special attention to cracking, peeling, and exposed pitting). If required by the detailed specification of the sensor, it can also be subjected to the corresponding tests as specified, in order to evaluate the effect of this test onto the sensor performance, AND the test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.9 Thermal radiation effect test

The thermal radiation effect test of the sensor shall be conducted in accordance with the provisions of GB/T 2423.24-2013.

After this test, in accordance with 5.1 and 5.3, CONDUCT the appearance and electrical performance test, AND the test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.10 Low atmospheric pressure effect test

The sensor shall, in accordance with the provisions of GB/T 2423.21-2008, be subjected to low atmospheric pressure effect test.

After this test, in accordance with 5.1 and 5.3, CONDUCT appearance and electrical performance test. The test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.11 Combined effect of low temperature/low pressure test

The sensor shall, in accordance with the provisions of GB/T 2423.25-2008, be subjected to the combined effect test of low temperature/low pressure.

After this test, in accordance with 5.1 and 5.3, CONDUCT appearance and electrical performance test. The test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.12 Combined effect of high temperature/low pressure test

The sensors shall, in accordance with the provisions of GB/T 2423.26-2008, be subjected to the combined effect of high temperature/low pressure test.

After this test, in accordance with 5.1 and 5.3, CONDUCT appearance and electrical performance test. The test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.13 Combined effect of low temperature/low atmospheric pressure/damp heat test

The sensor shall, in accordance with the provisions of GB/T 2423.27-2005, be subjected to the combined effect of low temperature/low pressure/damp heat continuous test.

After this test, in accordance with 5.1 and 5.3, CONDUCT appearance and electrical performance test. The test results shall comply with the requirements as specified in the detailed specifications of the sensor.

5.9.2.14 Sand and dust effect test

The sensors shall, in accordance with the provisions of GB/T 2423.37-2006, be subjected to sand and dust test.

Where:

$Y_{U_{ij}}$ - The j^th^ indicated value at the i^th^ point of the positive stroke;

$Y_{D_{ij}}$ - The j^th^ indicated value at the i^th^ point of the negative stroke;

$\overline{Y}_{U_i}$ - Mean value of positive stroke;

$\overline{Y}_{D_i}$ - Mean value of negative stroke;

n - The number of repeated tests;

m - The number of calibration points;

λ - Inclusion factor.

Note: The inclusion factor λ can be selected in accordance with one of the following principles: 1) in accordance with t distribution, take the confidence probability equal to 95%; 2) in accordance with the range method, taken as 2 ~ 3.

A.7 Accuracy (ξ)

A.7.1 Accuracy calculation principle

The accuracy of the sensor is a systematic reflection of the systematic error and random error, which depends on the systematic error band U_1 and random error band U_2.

A.7.2 Systematic error band U_1 of linear sensor

When the translational end base straight line is used, CONDUCT calculation in accordance with the equation (A.21):

$$U_1 = \pm\frac{1}{2}\left(|\overline{Y}_{U_i} - Y_{SB}|_{max} + |\overline{Y}_{D_i} - Y_{SB}|_{max}\right) \quad \cdots\cdots\cdots\cdots (A.21)$$

Where:

$\overline{Y}_{U_i}$, $\overline{Y}_{D_i}$ - The mean values of the positive stroke and the negative stroke as calculated respectively in accordance with the equation (A.1) and (A.2);

The thermal zero drift (α) of the sensor is calculated in accordance with the equation (A.35):

$$\alpha = \frac{\bar{Y}_L(t_2) - \bar{Y}_L(t_1)}{Y_{FS}(t_1) \cdot (t_2 - t_1)} \times 100\% \quad \cdots\cdots (A.35)$$

Where:

t_1 - The room temperature before the test, in the unit of degrees Celsius (°C);

t_2 - The high temperature or low temperature during the test, in the unit of degrees Celsius (°C);

$\bar{Y}_L(t_1)$ - At the room temperature t_1, the mean value of the zero indication of the sensor;

$\bar{Y}_L(t_2)$ - After constant temperature for the specified time at the specified high temperature or low temperature t_2, the mean value of the zero indication of the sensor;

$Y_{FS}(t_1)$ - At the room temperature t_1, the mean value of the full scale output value of the sensor;

In accordance with the equation (A.35), respectively CALCULATE the zero point temperature drift α+ andα- of the sensor at the high temperature or the low temperature, AND its symbol shall be selected in accordance with the calculation results, AND expressed in % FS/°C.

As for the intelligent pressure sensors, the thermal zero drift α is calculated in accordance with the equation (A.36):

$$\alpha = \frac{Y_L(t_2) - Y_L(t_1)}{Y_{FS}(t_1)} \times 100\% \quad \cdots\cdots (A.36)$$

Where:

$Y_L(t_2)$ - The extreme point zero output value under the upper limit compensation temperature OR lower limit compensation temperature OR extreme temperature drift point;

a - The band error of the entire temperature compensation zone;

A.13 Thermal full scale output drift (β)

$$\alpha_H = \frac{\overline{Y}_{\alpha_0} - \overline{Y}'_{\alpha_0}}{Y_{FS}} \times 100\% \quad \cdots\cdots (A.39)$$

Where:

$\overline{Y}_{\alpha_0}$ - Before the temperature cycle, the zero-point output mean value of room temperature;

$\overline{Y}'_{\alpha_0}$ - After the temperature cycle, the zero-point output value of the same room temperature;

Y_{FS} - The full scale output value of static calibration;

During application, it shall indicate the upper limit and the lower limit of the temperature cycle.

A.15 Thermal full scale output hysteresis (β_H)

The thermal full scale output hysteresis (β_H) of the sensor is calculated in accordance with the equation (A.40):

$$\beta_H = \frac{\overline{Y}_{\beta_0} - \overline{Y}'_{\beta_0}}{Y_{FS}} \times 100\% \quad \cdots\cdots (A.40)$$

Where:

$\overline{Y}_{\beta_0}$ - Before temperature cycle, the full scale output mean value of room temperature;

$\overline{Y}'_{\beta_0}$ - After temperature cycle, the full scale output value of the same room temperature;

Y_{FS} - The full scale output value of static calibration;

During application, it shall indicate the upper limit and the lower limit of the temperature cycle.

A.16 Effect of vibration on zero point (Z_0)

The effect of vibration on the zero point of the sensor (Z_0) is calculated in accordance with the equation (A.41)

------ The End ------