ITTC Quality System Manual

Sample Work Instructions

Work Instructions

Calibration of Bourdon Tube Pressure Gauges, Pressure Vacuum and Vacuum Gauges for General Use

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Disclaimer

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Verification regulation of Bourdon tube pressure gauge、pressure-vacuum gauge and vacuum gauge for general use

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Calibration of Bourdon Tube Pressure Gauges, Pressure Vacuum and Vacuum Gauges for General Use

1. SCOPE

This work instruction can be applied to the first, follow-up and in service calibration of MPa series of Bourdon tube pressure gauges, pressure-vacuum gauges and vacuum gauges for general use (hereinafter simply named pressure gauge) with the measuring range top limits of (-0.1 ~ 1000 Pa).

2. INTRODUCTION

Pressure gauges are mainly used to measure the pressure of liquid, gas, vapour, and vacuum.

The working principle of the pressure gauge is based on the tube edge displacement caused by the elastic deformation of the Bourdon tube under the action of pressure or vacuum. The displacement will be amplified through a mechanical transmission mechanism and then transferred to an indication device, the pointer of which shows the measured pressure or vacuum value on a display with the measuring units on it.

3. REQUIREMENTS FOR THE CALIBRATION

3.1 Accuracy grade and permissible errors for pressure gauges

Criteria for the accuracy grade and the allowable error for pressure gauges are shown in Table 1.

3.2 Indication error

The indication error within the measuring range should not exceed the allowable error shown in Table 1.

3.3 Return error

The return error within the measuring range should not exceed the absolute value of the allowable error given in Table 1.

3.4 Touch Displacement

The change of the indication should not exceed half the absolute value of the allowable error given in Table 1 when the gauge cover is touched.

Table 1

Accuracy grade	Allowable error % (calculated on percentage of measuring range)			
	Zero position		(90~100)% of measuring top limit	Rest part
	With shot pin	Without shot pin		

1	1	±1	±1.6	±1
1.6 (1.5)	1.6	±1.6	±2.5	±1.6
2.5	2.5	±2.5	±4	±2.5
4	4	±4	±4	±4
Note: Allowable error of 1.5 grade pressure gauge in service can be calculated upon the one of 1.6 grade. The accuracy grade can be unchangeable.				

3.5 Quiet Running Property of Pointer Inflexion

The pointer should move smoothly without any phenomena of jumping or getting entangled.

4. REQUIREMENTS FOR GAUGES IN COMMON USE

4.1 Exterior

4.1.1 Profile

The assembly of the parts of the pressure gauge should be solid without any flexible phenomenon.

The surface finish of a new pressure gauge should be consistently good without any phenomenon of obvious peeling.

The pressure gauges should have a safety hole with a dust-preventing device, except pressure gauges which are not allowed to leak sensor media.

The colour code shown in Table 2 should be marked on the pressure gauge on the basis of the sensor medium; a special medium's name should also be marked on the gauge. Oil ban with red colour should especially be marked on oxygen pressure gauges.

Table 2

Manometer medium	Colour of colour code
Oxygen	Sky blue
Hydrogen	Dark green
Ammonia	Yellow
Chlorine	Brown
Ethane	White
Other flammable gas	Red
Other inert gas	Black

4.1.2 Marking

The index plate should have the following items on it: manufacturer or trademark; name of product; measuring unit and digit; sign and number of the production license for the meter; sign "-" or word "negative " for vacuum; accuracy grade; number of production.

4.1.3 Indication Part

The gauge glass should be transparent without any colour and any default or damage which could affect the reading.

The index plate should be plane and bright, clean. All the marks should be clearly readable.

The indication edge of the pointer should be able to cover 1/3 ~2/3 of the length of the shortest scale line.

The breadth of the indication pointer should not exceed the breadth of the scale line.

4.1.4 Measuring Top Limit

The value of the top limit measuring value should be one of the following series: 1×10^n, 1.6×10^n, 2.5×10^n, 4×10^n, 6×10^n where: n is a positive integer, a negative integer or zero.

4.1.5 Division value

The division value should be one of the following series:

$$1\times10^n, 2\times10^n, 5\times10^n$$

where: n is a positive integer, a negative integer or zero.

4.1.6 Accuracy Grade

1, 1.6, 2.5, 4.

4.2 Zero position

4.2.1 Pointer With Limit Stop

The pointer of a pressure gauge with shot pin should locate near to the shot pin at the condition of vacuum or without pressure. “Grid contraction” should not exceed the absolute value of the allowable error given in Table 1.

4.2.2 Pointer Without Limit Stop

The pointer of the pressure gauge without shot pin should locate within the area of the zero position mark at the condition of vacuum or without pressure. The indication of the zero position should not exceed two times the absolute value of the allowed error in Table 1.

5. CALIBRATION

5.1 First, Follow-up and In Service Calibration

The measurement performance and the technical requirements for pressure gauges at the time of the first calibration, the follow up calibration and the calibration in service should fulfil the requirements of items 3.1 ~ 3.5 and 4.1 ~ 4.2 of this work instruction.

5.2 Calibration Conditions

5.2.1 Standard (Etalon)

Error requirements for the standard.

The absolute value of the allowable error for the standard should not exceed one-fourth of the absolute value of the allowable error of the calibrated pressure gauge.

The standards for selection are as follows:

A) Bourdon tube pressure gauge and vacuum gauge of precise class;
B) Piston pressure gauge;
C) Piston pressure-vacuum gauge
D) Liquid pressure gauge
E) Other pressure - metering standards which meet the error requirement.

5.2.2 Auxiliary Equipment

Auxiliary Equipment at Choice are :

- Pressure checker, vacuum checker;
- Hand pump, electric pump, vacuum pump;
- Oil-gas, oil-water isolator;
- Electric contact sender unit;
- Megohm meter: 500V.DC, 2.5 grade;
- Safety protection cover for the extra-high pressure gauge.

5.2.3 Environmental Conditions

- Ambient temperature : (20+5)°C ;
- Environmental relative humidity : not higher than 85% ;
- Environmental pressure : atmosphere

The pressure gauge should be at least kept for two hours in a place with the above listed ambient conditions.

5.2.4 Working Medium for the Calibration

The working medium for pressure gauges with top measuring limits not exceeding 0.25 MPa is clean air or the non-poisonous, non-harmful gas with stable chemical performance.

The working medium for pressure gauges with top measuring limits between 0.23 ~ 250 MPa is a non-corrosive liquid.

The working medium for pressure gauges with top measuring limits between 400 ~ 1000 MPa is a mixture of glycerine and ethylene glycol for medical use or a medium which meets the requirements of the standard.

5.3 Subject and Condition of Calibration

5.3.1 Exterior

This can be checked by eyesight and should meet the requirements given in 4.1.

5.3.2 Zero Point

The zero point can be checked by eyesight and should meet the requirements of item 4.2.

5.3.3 Calibration of Indication Error, Return error and Touch Displacement

The compression points of the standard and the pressure gauge with liquid as working medium should be basically at the same water column. If not, the pressure error caused by the liquid column difference should be taken into account.

The indication of the pressure gauge should be estimated based on one-fifth of the scale division value.

<u>Calibration method for indication</u>

The calibration of the indication of the pressure gauge can be carried out using the division lines identified with numbers. The pressure should be gradually and steadily increased (or reduced) during the time of the calibration. The

pressure (or vacuum) source should be cut when the indication rises above the top measuring limit, this pressure should be kept for 3 minutes, then the calibration can be done in return order by reducing (or raising) the pressure gradually and steadily according to the former calibration points.

Indication error

The difference between the indications of the calibrated pressure gauge and the standard before and after the calibrated gauge cover has been touched should comply with the requirements of item 3.2 for every calibrated point during calibration when the pressure is increased (or reduced) and reduced (or raised).

Return error

At the same calibrating point, the difference between the indications before and after the gauge cover has been touched should meet the requirement of item 3.3 when the pressure is raised (or reduced) and reduced (or raised).

Touch displacement

The change of the indication after the gauge cover has been touched should meet the requirements of item 3.4 for every calibrated point during calibration when the pressure is raised (or reduced) and reduced (or raised).

Quiet running of pointer inflection

This can be inspected visually and should comply with the requirements of item 3.5.

5.3.4 Calibration of the Vacuum Part of the Pressure-Vacuum Gauge

The pointer should point into the vacuum direction when the vacuum part of pressure gauges with pressure measuring top limits between 0.3 and 2.4 MPa is emptied.

The indications of two points should be calibrated during vacuum part calibration of pressure gauges with a pressure measuring top limit of 0.15 MPa.

The indications of three points should be calibrated during vacuum part calibration for pressure gauges with a pressure measuring top limit of 0.06 MPa.

The pressure withstand capability should be calibrated for vacuum gauges with vacuum degrees above 90% of the local atmospheric pressure.

5.3.5 Additional Calibration of Special Pressure Gauges

Non-oil inspection for oxygen pressure gauges

For ensuring the safety, a non-oil inspection should be done before and after the indication calibration. The method is as follows: Pure warm water should be poured into the Bourdon tube, which is swung for some time hereafter. Then the water can be thrown into a vessel filled with clean water. If there isn’t any colour oil shadow on the surface, the gauge can be considered to be without oil inside.

Calibration of pressure gauges with an inspection pointer

The indications of both the inspection and the indication pointer should be calibrated at the same time and the reading should be recorded. Then the indication of the indication pointer should be re-calibrated after the indication pointer has been brought back to the zero position. The difference of two indications of every calibrated point during pressure increase should not exceed the absolute value of the allowable error. The inspection pointer is not allowed to move when the gauge-cover is touched during the indication calibration.

Calibration of pressure gauges with double pointers and double tubes or with double pointers and single tube.

The two tubes' connectivity of a pressure gauge with double pointers & double tubes should be checked first. Two tubes should not feed through. The inspection method is as follows: One joint should be installed onto the pressure checker. Then the pressure should be increased up to the measuring top limit, the pointer of this joint should point to the measuring top limit; the other one should stay at the zero position. No oil should leak from the other joint. That means that the two tubes are not fed through each other. After that a pressure gauge can be installed using a three-way joint for the indication calibration. The indication difference of the two pointers of pressure gauges with double pointers & double tubes or double pointers & single tube should be inspected. The difference should not exceed the absolute value of the allowable error. The two pointers should not affect each other. For being easily distinguished the two joints should be painted the same colour as one of these two pointers respectively.

Calibration of the pressure gauge with the electric contact

A) Inspection of the insulation resistance

The reading of the megohm meter with a direct current working voltage of 500 V which is connected between the binding post and the outer cover of the pressure gauge and stabled for 10 seconds should not be less than 20MΩ. (the environmental temperature should be 15 ~ 35°C, the relative humidity should not exceed 80%).

B) Calibration of the deviation for the selected point and the switching point.

- The deviation of the switching activating point should be calibrated for two states of pressure raising and reducing for every selected point.
- Two points near 50% and 75% of the measuring range can be selected as upper limit, two points near 25% and 50% as lower limit.
- The selected pointer should be located at the selected value. The pressure then can be gradually and steadily raised or reduced (its speed should not exceed 1% of the measuring range when the indication pointer comes near to the selected value) until the signal comes to be connected or cut. The pressure value read from the standard is the connecting value or the cutting value.
- Deviation of the selected point
  The difference between the indication of the selected point (i.e. selected value) and the pressure value at the time when the signal is switched should meet the values in Table 3.
- Difference of switching
  The difference of the actual pressure values of the pressure gauge when the signal is connected and cut (switching) at the same selected point should meet the following criteria:
  Be not bigger than the absolute value of the indication allowable error for the direct

working style;
Be not bigger than 3.5% of the measuring range for the magnetic assisting direct working style.

Table 3

Accuracy grade	Allowable value of deviation of given point (calculated on percentage of measuring range)	
	Direct action mode	Mode of direct action with magnetic help
1	±1	±0.5～±4
1.6 (1.5)	±1.6	
2.5	±2.5	

6. TREATMENT OF CALIBRATION RESULTS

6.1 Calibration Protocol

For a pressure gauge qualified by the calibration a certificate with accuracy grade noted on it will be supplied.

For unqualified pressure gauges, an unqualified notice will be supplied with the unqualified items and contents noted (see Appendix B)

6.2 Calibration Period

The calibration period of the pressure gauge should not normally exceed half a year.

Appendix A. BASIC FORMAT OF CALIBRATION RECORD FOR PRESSURE GAUGE

Calibration record for pressure gauge No:
Gauge owner_____ Calibration date_____
Name of pressure gauge_____ Measuring range_____MPa
Manufacturer_____ Calibration temperature_____℃
Production number_____ Allowable error_____MPa
Grade number_____ Scale division value_____MPa
Exterior examination_____ Allowable error of etalon _____MPa

Standard pressure MPa	Indication of calibrated gauge being touched		Change of pointer being touched		Return error
	Pressure rising	Pressure falling	Pressure rising	Pressure falling	
Note:					

Calibration result: _____ grade has been reached. Checked by_____ on ____ ____, ____(date).
Calibrator: _____ on ____ ____, ____(date)

Note: The relevant contents can be added based on situation when the calibration record is used for the whole performance testing.

Appendix B. INSIDE PAGE FORMAT OF UNQUALIFIED NOTICE OF PRESSURE GAUGE

Calibration Result

Name of the etalon used in the calibration:

Accuracy grade:

Production number:

Temperature by the calibration:

Unqualified item and content:

Appendix C. TABLE OF ALLOWABLE ERROR CALCULATION FOR PRESSURE GAUGE

MPa

Accuracy grade / Top limit	1	1.6	2.5	4
0.1	±0.001	±0.0016	±0.0025	±0.004
0.16	±0.0016	±0.00256	±0.004	±0.0064
0.25	±0.0025	±0.004	±0.0062	±0.01
0.4	±0.004	±0.0064	±0.01	±0.016
0.6	±0.006	±0.0096	±0.015	±0.024
1	±0.01	±0.016	±0.025	±0.04
1.6	±0.016	±0.0256	±0.04	±0.064
2.5	±0.025	±0.04	±0.062	±0.1
4	±0.04	±0.064	±0.1	±0.16
6	±0.06	±0.096	±0.15	±0.24
10	±0.1	±0.16	±0.25	±0.4
16	±0.16	±0.256	±0.4	±0.64
25	±0.25	±0.4	±0.62	±1
40	±0.4	±0.64	±1	±1.6
60	±0.6	±0.96	±1.5	±2.4
100	±1	±1.6	±2.5	±4
160	±1.6	±2.56	±4	±6.4
250	±2.5	±4	±6.2	±10
400	±4	±6.4	±10	±16
600	±6	±9.6	±15	±24
1000	±10	±16	±25	±40