Metrology Society of Australia
MSA Test Method 2 - 2008
Calibration of Pressure Gauges

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Contents:

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1. Introduction

This Test Method describes test procedures for the calibration of pressure gauges. It is intended that this document be referenced instead of the Australian Standard AS1349-1986 for the testing of mechanical pressure gauges.

This document has been prepared in consultation with members of the Metrology Society of Australia (MSA) – Pressure Measurement Technical Group representing people from manufacturers, laboratories and users of calibration services. A forum at the MSA conference 2007 took feedback to the first revision. It is to be used in conjunction with ISO/IEC 17025, General and Supplementary Requirements for Calibration Laboratories.

Sections 2 – 7 form the test method requirements, while sections 8 – 10 are intended to be informative.

2. Scope

This document deals with testing mechanical pressure gauges designed for measuring gauge pressure, vacuum, differential pressure or absolute pressure which utilise a dial and pointer indication.
The gauges may utilise a bourdon tube, capsule, diaphragm sensitive or other sensitive element.
This document is not a standard for the manufacture of pressure gauges.

3. Accuracy Classes:

Reference shall be made to the accuracy class indicated on the dial, or to the manufacturer's specification unless the user has requested a specific accuracy class.

Gauges are manufactured to many standards and hence to many classes. Some typical accuracy classes include: 0.1, 0.25, 0.3, 0.6, 1.0, 1.6, 2.5, 3, and 4. The accuracy class represents the maximum allowable correction in % of range.

3.1 Test Gauges:

Gauges of accuracy class 0.3 or less are referred to in this Test Method as 'Test Gauges'. Test Gauges should be labelled 'Test Gauge' and shall be considered accuracy class 0.25 unless marked otherwise.

3.2 Industrial Gauges:

Gauges of accuracy class greater than 0.3 are referred to in this Test Method as 'Industrial Gauges'.

If the accuracy class is not marked on the gauge and the manufacturer's specification is unknown, the following rule will apply:-
Industrial gauges will be class 1.0, except for gauges less than 70mm nominal dial diameter, which will be class 3.0.
Gauges shall be labelled if this rule does not apply.

4. Reference Equipment:

Reference equipment shall be certified by an accredited laboratory and be traceable to national or international standards.

The uncertainty of the reference instrument shall be less than or equal to 1/4 of the accuracy specification of the gauge under test at any test point, except when test gauges are used as below. (see notes)

Test Gauges used for Testing Industrial Gauges:

In the case where a test gauge is used as a reference the test gauge shall have a range not more than 1.5 times that of the industrial gauge.

5. Gauges for Oxygen Service:

The laboratory shall have procedures for the safe handling of gauges for use on oxygen where contamination with oil can present substantial risk to the end user of the gauge.

6. Test Procedure:

6.1 Overload Testing:

Overload testing is not specified in this procedure.

6.2 Environment:

The temperature of the laboratory shall be maintained at 20 ± 2°C for the calibration of test gauges only.

Instruments under test shall be given adequate time to come near to room temperature.

6.3 Position:

Unless otherwise specified, gauges shall be tested with the dial vertical and the mid-scale point in the 12 o'clock position.

Gauges tested in another position shall have the position marked on the dial or a label on the gauge case.

6.4 Test Fluid:

The test fluid will be suitable for the gauge. Test Gauges with ranges of 2500 kPa or less shall be tested on liquid or gas depending on which fluid they will be used on.

(If a gauge of range ≤2500 kPa is intended to be used on air is instead tested on liquid, or visa versa, a significant error may occur because of the increased weight of the bourdon tube when filled with liquid.)

6.4 Test Points:

Gauges should be tested in SI units if the gauge can be read in SI units

The test points are to be spread over the range of the gauge and shall include the maximum scale value. Zero shall be included unless zero is either not free (pointer stop) or not well marked.

The number of test points is dependent on the gauge class:

Table 1: Minimum Number of Test Points	
Test Gauges	8 points
Industrial Gauges	4 points

For vacuum gauges a test point near their maximum value is acceptable.

Differential Gauges may be tested with one port open to atmosphere.

6.5 Gauge Readings:

The gauge will be taken to the maximum scale value and back to zero before testing.

Readings will be made with rising and falling pressures and the gauge will be tapped lightly before each reading. Two sets of readings are required for test gauges only.

Readings may be made by applying a pressure which will bring the gauge to the mark and observing the reference instrument.

Alternatively, a pressure near to the nominal value may be applied and the gauge read. In this case, when the applied pressures are more than $1/8^{th}$ of the resolution away from the nominal test point, the corrections shall be rounded to one significant number more than the gauge resolution.

The method of observation shall result in the uncertainty in the correction being no larger than the gauge accuracy class given in section 3. (See Notes)

7. Reporting of Results:

7.1 Reports:

A report shall include the following:

1. Date of test
2. Test report number
3. Serial number of the gauge
4. Description of the gauge including nominal dial diameter
5. Position of the gauge during testing
6. Room temperature and tolerance
7. Table of results including the nominal pressure of each test point, mean readings and corrections for both rising and falling pressure
8. Statement detailing whether the gauge was adjusted and the maximum 'As Found' correction. A set of 'As Found' readings is recommended but not mandatory
9. Uncertainty in the corrections. Uncertainty shall be calculated for at least one pressure point, at the 95% confidence level, and in the units of the gauge readings
10. Conversion factor used if not SI units
11. Any other information important to the performance of the gauge

7.2 Compliance Statement:

The report shall contain a statement of compliance to this Test Method.
The compliance statement shall include a description of the accuracy specification to which it conforms. (see notes)

8. Informative Notes:

Reference Equipment Uncertainty (4):
The reference instrument uncertainty should consider the uncertainty from its calibration report and an allowance for drift since calibration.

For digital references, the manufacturer's one year accuracy specification should be used as a drift allowance in the absence of other data.

Compliance Statements (7.2 & 6.5):

It is normal to accept a gauge as complying only if the measurement uncertainty added to the correction are within the tolerance.
However, this would put this test method out of step with all other current standards for pressure gauges. Therefore the gauge is deemed to comply with this test method if the correction is no larger than the tolerance and the uncertainty of the correction is not larger than the accuracy tolerance.

As an example, a Class 0.25 test gauge may have a correction as large as 0.2% of range and an uncertainty of measurement equal to 0.25% of range. Theoretically, this means a reading could be out by 0.45% - but this is the implied position of other standards.

Uncertainty Calculations (7.1):

Uncertainty calculation should at least consider contributions from the reference equipment, and the gauge under test. Some notes on some components follow:

Repeatability:

Standard uncertainty due to repeatability may be estimated from several readings at one point using:-
u_{Rep} = (Max reading – Min reading)/√3.

Repeatability for all readings may be estimated by its evaluation at one test point unless variation is observed through the range during testing.

Resolution:

Standard uncertainty due to resolution may be estimated using:-
u_{Res} = Resolution/√3

The uncertainty due to resolution needs to be included only if the uncertainty due to repeatability is zero. The estimate of repeatability involves resolution and including both terms tends to be over-conservative. Uncertainty in these terms needs to consider the number of divisions, width of the pointer, width of the scale marks and parallax error.

9. Definitions

Corrections: The value to be added to a test instrument reading to indicate the true pressure. They are opposite in sign to reading errors.

Gauge pressure: Pressure that is relative to atmospheric pressure

Absolute pressure: Pressure that is relative to full vacuum such as that measured by a barometer.

Hysteresis: The difference in readings obtained from a test on falling instead of rising pressures.

Range: The span between bottom and full scale of measured values.

Resolution: The minimum discrimination the scale is read to.

Repeatability: The variation in readings at a given test point observed during the time of testing.

10. References:

AS 1349 (1986) - *Bourdon Tube Pressure and Vacuum Gauges*

BS EN 837-1: 1996 *Bourdon Tube Pressure Gauges*

Assessment of Uncertainties of Measurement
(R.R. Cook 1999)