British Standard

BRITISH STANDARD

BS 6174:1982

Incorporating Amendment No. 1

Specification for

Differential pressure transmitters with electrical outputs

UDC 621.317.39:531.787.91

Cooperating organizations

The Industrial-process Measurement and Control Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

British Gas Corporation*
British Industrial Measuring and Control Apparatus Manufacturers' Association*
British Steel Corporation
Control and Automation Manufacturers' Association (BEAMA)
Department of Industry
Department of Industry (Computers Systems and Electronics)
Department of Industry (National Engineering Laboratory)
Department of the Environment (Water Engineering Division including Water Data Unit)
Electrical, Electronic, Telecommunications and Plumbing Union
Electricity Supply Industry in England and Wales*
Energy Industries Council*
Engineering Equipment Users' Association*
Institute of Measurement and Control*
Institution of Gas Engineers*
Oil Companies Materials Association*
Post Office Engineering Union
Scientific Instrument Manufacturers' Association*
Sira Institute

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

British Pressure Gauge Manufacturers' Association
Chemical Industries Association
Department of Energy Gas Standards
National Coal Board

This British Standard, having been prepared under the direction of the Industrial-process Measurement and Control Standards Committee was published under the authority of the Board of BSI and comes into effect on 26 February 1982

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Contents

Foreword

This standard has been prepared under the direction of the Industrial-process Measurement and Control Standards Committee.

The SI pressure unit "pascal" has been used throughout this standard. However, since a large sector of British industry is committed to the use of the pressure unit "bar" and intends to maintain this position, the equivalent in bars has been given in brackets after the value in pascals.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies requirements for d.c. powered electrical transmitters with analogue direct current output used in differential pressure measurement.

This standard applies only to transmitters with a linear relationship between differential pressure input and current output for general industrial use, and does not apply to aerospace, marine, laboratory and medical requirements.

2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this standard the following definitions apply.

3.1
measured error

the largest deviation of the output of the transmitter from its corresponding ideal value, obtained with both increasing and decreasing inputs

NOTE Measured error is expressed as a percentage of span and is determined in accordance with **A.2.5**.

3.2
hysteresis

that property of an element evidenced by the dependence of the value of the output, for a given excursion of the input, upon the history of prior excursions and the direction of the current traverse

NOTE This is a common usage definition which includes hysteresis error and dead band. That portion of the difference which is dependent on the history of prior excursion is hysteresis error while that portion attributable to dead band may be determined by a conventional dead band test.

3.3
hysteresis error

that portion of hysteresis attributable to energy absorption in the elements of a measuring instrument

NOTE Hysteresis error should be determined by subtracting the value of dead band from the maximum measured separation between upscale-going and downscale-going indications of the measured variable, during a full-range traverse unless otherwise specified.

3.4
dead band

the largest change in input that can be effected without causing a detectable change of output

3.5
range

the region between the limits within which a quantity is measured, received or transmitted expressed by stating the lower and upper range values

3.6
lower range value

the lowest value of the measured variable that a device is adjusted to measure

3.7
upper range value

the highest value of the measured variable that a device is adjusted to measure

3.8
span

the algebraic difference between the upper and lower range values

3.9
over-range

the condition in which the value of the input signal exceeds its upper range value or goes below its lower range value

3.10
repeatability

the closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction, for full-range traverses

3.11
transmitter

measuring transducer whose output is a standardized signal

4 Classification

The performance characteristics of transmitters are classified under four headings as follows:

a) accuracy class;

b) temperature coefficient class;

c) static pressure class;

d) over-range class.

For fixed range transmitters the performance characteristics shall be identified by a four-element code in the above order (see Table 1 to Table 4), followed by the range of pressure within which the characteristics apply.

For example: 0.5A3B, 0 kPa to 200 kPa (0 bar to 2 bar)

For adjustable range transmitters the performance characteristics shall be identified by four-element codes appropriate to ranges corresponding at least to the maximum and minimum spans.

For example:

0.5A3B 0 kPa to 200 kPa (0 bar to 2 bar)

1B3C 0 kPa to 25 kPa (0 bar to 0.25 bar)

5 Performance

5.1 Reference conditions. Reference conditions shall be as given in **A.1**.

5.2 Accuracy. When tested in accordance with **A.2** the combined error given by the sum of the modulus of the measured error and the repeatability, under reference conditions shall not exceed the values given in Table 1.

Table 1 — Limits of combined error

Accuracy class	Limits of combined error, % of output span
0.1	± 0.1 %
0.2	± 0.2
0.5	± 0.5
1.0	± 1.0
2.0	± 2.0
5.0	± 5.0

NOTE 1 The requirements of **5.5.2.2**, **5.5.2.4**, **5.9.3**, **5.11** and **5.12** need to be taken into account in determining the accuracy class given in Table 1.

NOTE 2 The error of a local output current indicator, if fitted, is not included in the calculation of the error of the transmitter.

5.3 Temperature variations

5.3.1 *General.* The transmitter shall be capable of continuous operation within an ambient temperature range of – 25 °C to + 70 °C.

5.3.2 *Effect of temperature variations.* The effect of temperature variations shall be tested in accordance with **A.3**.

At any temperature between – 25 °C and + 70 °C the average coefficients of zero shift and span change relative to 20 °C each shall not exceed the values given in Table 2.

Table 2 — Limits of zero shift and span change with temperature, and limits of residual changes after temperature excursions

Temperature coefficient class	Limits of zero shift and span change, % of output span per °C	Limits of residual zero shift and span change, % of output span
A	± 0.005	± 0.05
B	± 0.010	± 0.10
C	± 0.020	± 0.20
D	± 0.050	± 0.50
E	± 0.100	± 1.00

After a temperature excursion from 20 °C to any temperature between – 25 °C and + 70 °C, the residual zero shift and span changes each shall not exceed the values given in Table 2.

5.4 Humidity

5.4.1 *General.* When tested in accordance with **A.4** the transmitter shall be capable of continuous operation at a relative humidity of up to 95 %. This also applies for periods of up to 4 h with the adjustment covers removed.

5.4.2 *Effect of relative humidity variations.* There is no additional change specified for a variation in relative humidity. When the transmitter is subjected to the test described in **A.4**, the errors shall not exceed the values given in Table 2.

When the transmitter is subjected to the test with covers off described in **A.5**, the errors shall not exceed the values given in Table 2.

5.5 Electrical characteristics

5.5.1 ***Output circuit***

5.5.1.1 *General.* The electrical output of the transmitter shall have a range of 4 mA to 20 mA d.c., or 0 mA to 20 mA d.c. The transmitter shall be capable of operation when the output terminals are isolated from earth and when either terminal is earthed.

5.5.1.2 *Ripple and noise.* The peak-to-peak value of internally generated ripple and noise appearing in the output current shall not exceed the values stated in Table 1 up to maximum of 1 % of the output span over a frequency range of zero to 100 kHz.

The appropriate test shall be performed by measurement of the peak-to-peak ripple content of the output with 10 %, 50 % and 90 % input signals at minimum and maximum resistive load.

5.5.1.3 *Stability.* The output of the transmitter shall be stable and the ripple shall comply with the requirement of **5.5.1.2** when the manufacturer's recommended maximum resistive load is shunted by any capacitance up to a maximum of 1 μF.

5.5.1.4 *Effect of earthing output.* When tested in accordance with **A.6** the change in output owing to an earth connection shall not exceed 0.25 % of the output span.

5.5.2 ***Power supply and load***

5.5.2.1 *General.* Both two-wire and three-wire transmitters shall be capable of continuous operation from a d.c. supply with any value from 20 V to 30 V. Two-wire transmitters shall be capable of supplying current to a resistive load between 0 Ω and at least 300 Ω. Three-wire transmitters shall be capable of supplying current to a resistive load between 0 Ω, and at least 500 Ω.

NOTE 1 In some circumstances, e.g. in intrinsically safe systems, the use of higher external resistive loads may be negotiated between the supplier and user.
NOTE 2 For two-wire transmitters, the output signal is carried on the same pair of wires that provide the power supply. For three-wire transmitters, one wire is common to the power supply and the output signal.

5.5.2.2 *Effect of power supply variations.* The change in output as the voltage is varied from 20 V to 30 V, with a load of 300 Ω, for two-wire transmitters, or 500 Ω, for three-wire transmitters, shall not exceed 0.05 % of the output span for accuracy class 0.1, 0.1 % for accuracy class 0.2, 0.2 % for accuracy classes 0.5, 1 and 2 and 0.5 % for accuracy class 5.

The appropriate test shall be performed with the input pressure adjusted to the value required to give full range out-put.

5.5.2.3 *Supply aberrations.* After supply interruptions are applied to the transmitter under the conditions specified in **A.7** the transmitter shall be capable of continuous operation in accordance with **5.2**.

5.5.2.4 *Load resistance.* When the load resistance is varied from 0 Ω, to maximum, and vice versa at any fixed supply voltage between 20 V and 30 V, the total variation in output current shall not exceed 0.05 % of the output span for accuracy class 0.1, 0.1 % for accuracy class 0.2, 0.2 % for accuracy class 0.5, 1 and 2 and 0.5 % for accuracy class 5.

5.5.3 ***Interference***

5.5.3.1 Variations in the mean d.c. level of the output current, due to spurious signals of up to 250 V 50 Hz and 50 V d.c. in common mode, when tested in accordance with **A.9**, or 1 V 50 Hz in series mode, when tested in accordance with **A.10**, shall not exceed 0.1 % of the output span at any output value.

The 250 V a.c. common mode signal shall be derived from a source with an impedance between 0.5 MΩ and 10 MΩ.

5.5.3.2 For transmitters consisting of two or more separate units connected by a screened cable, variations in the mean d.c. level of the output current, due to a spurious signal of 50 mA 50 Hz along the length of screen, shall not exceed 0.1 % of the output span at any output value.

The appropriate test shall be performed as follows.

Set the output to 50 % of span. Isolate one of the instrument cases from earth, and pass a current of 50 mA, 50 Hz square wave through the cable screen. Measure any change of the output.

5.5.3.3 For transmitters stated by the manufacturer to be suitable for use in the presence of r.f. interference, the transmitter shall be capable of operation in the presence of electromagnetic radiation of field strength 10 V/m in any orientation with respect to the field and at frequencies in the following ranges:

27 MHz to 28 MHz
68 MHz to 88 MHz
100 MHz to 108 MHz
138 MHz to 174 MHz
420 MHz to 470 MHz

The change in output owing to application of the field shall not exceed 1 % of the output span. For the purpose of testing, the output is set to 50 % of span. The manufacturer shall state the method of test employed to check compliance with these requirements.

5.6 Pressure

5.6.1 *Static (process) pressure.* When the static pressure applied to the transmitter is varied from atmospheric pressure to the manufacturer's limit or to 10 MPa (100 bar) whichever is less, under the conditions specified in **A.1**, the average coefficients of zero shift and span change relative to conditions at atmospheric pressure each shall not exceed the values given in Table 3.

For a transmitter for use where the static pressure is reduced below atmospheric pressure, the change in output shall not exceed 0.1 % of the output span.

Table 3 — Limits of zero shift and span change with pressure

Static pressure class	Limits of zero shift and span change % of output span per MPa (10 bar)
1	± 0.02
2	± 0.05
3	± 0.10
4	± 0.20
5	± 0.50

5.6.2 *Over-ranging.* The residual zero shift and span change, due to the application of an asymmetrical input pressure in either direction up to the maximum static pressure specified by the manufacturer under the conditions given in **A.12**, shall not exceed the values given in Table 4.

5.7 Mounting position. When tilted at an angle of up to 10° in any direction from the manufacturer's normal recommended mounting position, the transmitter shall be capable, after any necessary zero adjustment, of continuous operation in accordance with **5.2**.

Table 4 — Limits of residual changes after pressure excursions

Over-range class	Limits of residual zero shift and span change % of output span
A	± 0.1
B	± 0.2
C	± 0.5
D	± 1.0
E	± 2.0
F	± 5.0

5.8 Mechanical shock. Transmitters shall be capable of withstanding mechanical shock of the severity described in **A.13**.

5.9 Vibration

5.9.1 *General.* Transmitters shall be capable of withstanding vibration of the severity described in **A.14**. For the test performed with power applied to the transmitter, the input shall be set to 50 % of span.

5.9.2 *Effect of vibration during the test.* The magnitude of d.c. and peak-to-peak a.c. output changes due to vibration which exceed 1 % of output span and the frequency bands in which the changes occur, shall be in accordance with the values stated by the manufacturer.

5.9.3 *Effect of vibration after the test.* The zero shift and span change shall each not exceed 0.05 % of the output span for accuracy class 0.1, 0.1 % for accuracy class 0.2 % of the output span for accuracy classes 0.5, 1 and 2, and 0.5 % for accuracy class 5.

5.10 Start-up drift. For the first 60 min after the power supply is switched on, the requirements of **5.2** do not apply because of the possible effect of start-up drift. When the transmitter is tested in accordance with **A.15**, however, the difference between the values measured after 5 min and after 60 min shall not exceed 0.2 % of output span. After 60 min, the requirements of **5.2** shall apply.

5.11 Long-term drift. Test the long term drift in accordance with **A.16**.

The average long term drift shall be expressed as a percentage of output span per 30 days, and the slope of the best fit straight line shall be drawn through experimentally determined points. No individual point shall exceed three times the values given in Table 5 after correcting for ambient influences as in **A.16**.

The average long term drift owing to cumulative errors from all internal sources shall not exceed the values given in Table 5.

5.12 Stability with cycling input. After the transmitter has been subjected to the test described in **A.17** the zero shift and span change each shall not exceed one-half of the values of the limits of error given in Table 1 for the accuracy class of the transmitter.

5.13 Step response. The response times of the transmitter under reference conditions for an input step from 10 % to 90 % of span shall be in accordance with the values stated by the manufacturer. These shall be expressed in terms of both a) and b) as follows:

a) the time for the output to change from 0 % to 63 % of the output step interval;

b) the time for the output to reach and remain within 1 % of span of its steady value.

Table 5 — Limits of average long-term drift

Accuracy class	Limits of average long-term drift, % of output span per 30 days
0.1	± 0.025
0.2	± 0.075
0.5, 1.0 and 2.0	± 0.150
5.0	± 0.300

6 Materials and construction

6.1 Materials and finishes. Materials and finishes of construction shall be capable of withstanding the limits of influence conditions specified in **5.3**, **5.4** and **5.8**.

NOTE Materials and finishes capable of withstanding other conditions not specified in this standard should be the subject of notification and agreement between the supplier and purchaser.

6.2 Construction

6.2.1 *General.* The case assembly, when installed according to the manufacturer's recommendations, shall be dust-proof and water-proof to provide a degree of protection in accordance with IP 65 as specified in BS 5490.

6.2.2 *Proof pressure test.* The enclosures subject to static pressure shall be capable of withstanding the proof pressure test described in **A.17**. When the pressure has been applied for at least 5 min there shall be no visible leak. After the test the transmitter shall be capable of readjustment to its original accuracy class.

6.2.3 *Pressure connections.* Pressure connections shall be ¼ in or ½ in as specified in BS 21, or ¼ in or ½ in USA standard taper pipe thread (NPT) specified in ANSI B2.1:1968[1)].

Facilities shall be provided for fitting standard valve manifolds having 54 mm (2⅛ in) centre spacing between the pressure connections.

[1)] ANSI B2.1:1968, "*Specifications for pipe threads (except dryseal)*".

6.2.4 *Electrical connections.* Terminals other than earthing terminals shall be sufficiently protected to prevent accidental contact.

External connections shall be clearly marked to enable their functions to be identified.

Apertures for electrical connections and terminations shall be suitable for fittings of sizes as specified in BS 4568, or for ½ in USA standard taper pipe thread (NPT) specified in ANSI B2.1:1968[2)].

6.2.5 *Insulation resistance.* The insulation resistance between the external electrical connections and the case or frame shall be not less than 20 MΩ when measured at a potential of 250 V d.c. or at another voltage specified by the manufacturer.

7 Marking

Each transmitter or separate unit of the transmitter shall be clearly marked with the manufacturer's name, model number, serial number and the maximum safe working pressure.

The high and low pressure connections shall be clearly marked.

Marking shall be applied to a part which is not normally detached when obtaining access to the transmitter.

[2)] ANSI B2.1:1968, "Specifications for pipe threads (except dryseal)".

Appendix A Test methods

A.1 Environmental test conditions

A.1.1 *Range of ambient conditions for test measurements.* The range of ambient conditions for test measurements are as follows.

Temperature	15 °C to 35 °C
Relative humidity	45 % to 75 %
Atmospheric pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)
Electromagnetic field	Value to be stated, if relevant

The rate of temperature change during any test shall not exceed 1 °C in 10 min.

NOTE These conditions may be equivalent to normal operating conditions.

A.1.2 *Standard reference atmosphere.* The standard reference atmospheres shall be as follows.

Temperature	20 °C
Relative humidity	65 %
Atmospheric pressure	101.3 kPa (1 013 mbar)

NOTE 1 This standard reference atmosphere is that atmosphere to which values measured under any other atmospheric conditions are corrected by calculation. It is recognized that in many cases a correction factor for humidity is not possible. In such cases the standard reference atmosphere takes account of temperature and pressure only.

NOTE 2 This atmosphere is equivalent to the normal reference operating conditions usually identified by the manufacturer.

A.1.3 *Standard atmosphere for reference measurements.* When correction factors to adjust atmospheric-condition sensitive parameters to their standard reference atmosphere values are unknown, and measurements under the recommended range of ambient atmospheric conditions are unsatisfactory, repeated measurements under closely controlled atmospheric conditions may be conducted.

For the purpose of this standard, the atmospheric conditions given in Table 6 are for reference measurements.

Table 6 — Atmospheric conditions for reference measurements

Atmospheric condition	Nominal value	Tolerance
Temperature	20 °C	± 2 °C
Relative humidity	65 %	± 5 %
Atmospheric pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)	—

NOTE For tropical, sub-tropical, or other special requirements, alternate reference atmospheres may be identified.

A.2 Accuracy related tests

A.2.1 *Preconditioning.* All devices under test, and associated test equipment shall be allowed to stabilize under steady-state test conditions. Test conditions that could influence the test shall be noted.

State the uncertainty of measurements of the measuring systems used for the tests in the test report.

NOTE The uncertainty of measurement of the measuring systems should be smaller than or equal to one-fourth of the stated limits of combined error of the instrument tested.

Distribute the number of test points to determine the desired performance characteristic of a device over the range. Not less than five points, and preferably more, shall include points at or near (within 10 %) the lower and upper range values. The number and location of these points shall be consistent with the degree of exactness desired and the characteristic being evaluated.

Before making observations, exercise the device under test by three full-range traverses in each direction.

At each point being observed, hold the input steady until the device under test becomes stabilized at its apparent final value.

A.2.2 *Measurement cycle.* Test conditions shall be maintained and the device under test shall be preconditioned as indicated in **A.2.1**. Output values for each chosen input value and for one full range tranverse in each direction shall be measured.

The input shall be applied in such a way that neither input or output over-range occurs. The final input shall be approached from the same direction as the initial input.

A.2.3 *Measurement tabulation.* Present the output values obtained during the measurement cycle described in **A.2.2** in the form of a table.

A.2.4 *Deviation curve.* For the purpose of the following computations prepare a deviation curve to show conformity to the ideal output curve. Observe the difference between each output value and determine its corresponding ideal output value.

The difference is the deviation and it is expressed as a percentage of ideal output span. The deviation is plotted against percentage input. A positive deviation denotes that the observed output value is greater than the ideal output value.

A.2.5 *Measured error.* Determine the measured error from five measurement cycles. It is the greatest positive or negative deviation of any average value with either increasing or decreasing inputs. Measured error is expressed as a plus and minus percentage of output span.

A.2.6 *Dead band.* Measure the dead band approximately at the minimum and maximum input values and at a point midway between these values by proceeding as follows:

a) slowly vary (increase or decrease) the input until a detectable output change is observed;

b) observe the input value;

c) slowly vary the input in the opposite direction until a detectable output change is observed;

d) observe the input value.

The increment through which the input signal is varied [the difference between steps b) and d)] is the dead band. It is determined from a minimum of 5 cycles [steps a) to d)]. The maximum value is recorded.

Dead band is expressed in percent of input span. It is unnecessary in most cases to continue the test if the dead band is less than 0.1 %.

A.2.7 *Repeatability.* Determine the repeatability directly from the deviation values of a number of test cycles, and compute it as twice the root mean square of the deviations from the measured at each test point for increasing and decreasing inputs separately.

Repeatability is expressed as a percentage of the output span using the greatest numerical value obtained above.

A.3 Ambient temperature test

(See BS 2011-2.1A, BS 2011-2.1B and BS 2011-2.1N) Measure the changes in the value of the output signal at the maximum and minimum operating temperatures specified by the manufacturer, and at each of the following ambient temperatures:

+ 20 °C, + 40 °C, + 55 °C, + 70 °C, 0 °C, – 10 °C, – 25 °C, + 20 °C.

Change the temperature step by step, and without any adjustment perform a second temperature cycle.

The tolerance for each temperature shall be ± 2 °C. Allow sufficient time for stabilization of the temperature of the equipment being tested.

A.4 Humidity test (see BS 2011-2.1 Ca)

A.4.1 Measure the output under ambient test conditions and maintain the transmitter at ambient test conditions (see **A.1.1**) for 24 h. Take a set of reference measurements. Then maintain the transmitter in a chamber at atmospheric pressure for a period of at least 48 h, at a temperature of 40 ± 2 °C, and at a humidity of not less than 95 %. Switch the transmitter on for the final 4 h of the above period and take measurements immediately following this period at intervals of 20 % of the output span.

A.4.2 With the transmitter still in operation, allow the temperature to fall below 25 °C in not less than 1 h. Keep the chamber closed so that saturation can take place during this period. Determine any changes in lower or upper range values owing to this condition immediately following stabilization.

A.4.3 After this test, conduct a visual inspection to check effects such as signs of flashover, accumulations of condensate and deterioration of components.

A.4.4 Immediately after a further period of 24 h at ambient conditions, determine the transmitter error at intervals of approximately 20 % span for rising and falling signals. Record changes in error from the original values.

A.5 Humidity test with covers off

Carry out the test as described in **A.4.1**, **A.4.3** and **A.4.4** but maintain the transmitter at 40 °C for 6 h with a relative humidity of 65 ± 5 %, followed by 4 h with a relative humidity of 95 ± 2 %.

A.6 Earthing test

This test applies only to transmitters with terminals isolated from earth.

Measure the changes caused by connecting, in turn, each of the terminals to earth. Record any transient charges.

NOTE Care should be taken to eliminate any effect due to the earthing of input circuit of the test apparatus.

A.7 Power supply interruptions test

The purpose of this test is to determine the behaviour of the instrument on switching from the normal specified supply to a standby supply. The input is held constant at 50 % of span.

Interrupt the power supply for 5 ms, 20 ms, 100 ms, 200 ms and 500 ms, and record the following values:

a) the maximum transient negative and positive change in output;

b) the time taken for the output to reach 99 % of its steady state value following reapplication of power;

c) any permanent change in output.

In order to obtain an appropriate accuracy, repeat the test ten times with random phase for each value, the period of time between two tests being at least ten times the duration of the test.

A.8 *Text deleted*

A.9 Common mode interference test

This test applies only to transmitters with terminals isolated from earth.

Measure the changes in the output caused by the superposition of an a.c. signal of 250 V r.m.s. at mains frequency between earth and each input and output terminal in turn.

NOTE If the manufacturer specifies a value less than 250 V then this lower value should be used instead.

A.10 Series mode interference test

A.10.1 *Principle.* This test is used to determine the influence on the output signal of an alternating voltage (series mode voltage) at mains frequency superimposed on the output signal.

The superimposed voltage is obtained across the secondary of a transformer shunted with a parallel resistance of 10 Ω, maximum and connected in series with the load resistance.

A.10.2 *Procedure.* Earth the side of the parallel connection of the transformer secondary and the loading resistor not directly connected to the transmitter. Carry out measurements for output values of 10 % and 80 %.

By adjusting the primary voltage, set the series mode voltage across the loading resistor to 1 V peak value, with the connection to the transmitter open circuit. Then connect the transmitter into the circuit, and measure the change in the mean value of the output signal. Set the phase of the transformer voltage so that this change of the output current has its maximum value. Record this change of the mean d.c. value of the output signal if it is smaller than 0.5 % of the actual span. If the measured change is greater than 0.5 %, reduce the series mode voltage by reducing the primary voltage until the change in the output signal equals 0.5 %. Record the corresponding value of the series mode voltage.

A.11 Static (process) pressure test

Measure the changes in zero and span caused by changing static pressure in the measuring element at the minimum and maximum span. Change the pressure in four equal steps from atmospheric to the full working pressure of the instrument. For some transmitters, also carry out this test below the atmospheric pressure.

NOTE Due attention should be paid to the change of pressure rating caused by a change of temperature and to the difficulty of measuring the change of span with changing static pressure.

A.12 Over-ranging test

Measure the changes in output zero and span which result from over-ranging at the minimum and maximum span. Apply the input lower range value and increase it slowly from this value to the maximum over-range specified by the manufacturer.

After the over-range has been applied for 2 h, reduce the input to the nominal lower range value. After a further 30 min have elapsed, determine the output zero and the span.

Carry out over-ranging in both directions.

A.13 Mechanical shock test (see BS 2011-2.1Ec)

A.13.1 *Principle.* This test used to represent knocks and jolts likely to occur during repair work or rough handling during use and to assess a minimum degree of ruggedness.

A.13.2 *Procedure.* Record lower range value and span. Stand the transmitter in its normal position or use on a smooth, hard, rigid surface of concrete or steel. Tilt it about one bottom edge so that the distance between the opposite edge and the test surface is 25 mm, or so that the angle made by the bottom and the test surface is 30° whichever condition is the less severe. Then allow the transmitter to fall freely on the test surface.

Subject the transmitter to one drop about each of the four bottom edges.

After the test, examine the transmitter for change and record any change in lower range-value and span.

A.14 Mechanical vibrations test
(see BS 2011-2.1Fc)

A.14.1 *Principle.* To measure the changes induced by mechanical vibrations likely to be met in service, and to ensure that the robustness of the transmitter is satisfactory in these conditions.

The vibration tests are performed first on the transmitter with normal supply and 50 % input, then without supply and input.

NOTE Without supply resonances can be different, depending on the type of transmitter.

A.14.2 *Procedure*

A.14.2.1 *Preparation for test.* Mount the transmitter in accordance with the manufacturer's instructions for normal installation on a vibration table, and subject it to sinusoidal vibrations in three mutually perpendicular axes, one of which is the vertical direction. The rigidity of the vibration table, the mounting plate and any mounting brackets used for supporting the instrument shall be such that the impulse is transferred to the instrument with the minimum of loss, yet with no increase in amplitude or generation of harmonics.

A.14.2.2 *First stage: initial resonance search.* The object of this stage is to investigate the transmitter response to vibrations, to determine resonance frequencies and to collect information which is necessary for the final resonance search.

During the frequency sweeping, note frequencies that give rise to significant changes in the output signal and mechanical resonances.

Note all the amplitudes and frequencies at which these effects occur, in order to compare them with those found during the final resonance search (see **A.14.2.4**).

The frequency sweeping shall be continuous and logarithmic. The sweep rate shall be approximately 0.5 octave per minute. The frequency ranges used for the evaluation shall be as given in Table 7.

Table 7 — Frequency ranges for evaluation

Installation	Vibration frequency	Peak amplitude	Peak acceleration
	Hz	mm	m/s^2
Field (low vibration level)	1 to 10	1.000	—
	10 to 60	0.069	—
	60 to 500	—	9.8

NOTE The cross-over frequency between constant amplitude and constant acceleration is nominally 60 Hz.

A.14.2.3 *Second stage: endurance conditions by sweeping.* Perform the test described in **A.14.2.2** again by sweeping the frequency range with a sweep rate of 1 octave per minute.

Carry out this stage of the test for 6 h, applying the vibrations for 2 h in each of the three mutually perpendicular directions.

A.14.2.4 *Third stage: final resonance search.* Carry out the final resonance search in the same way as the initial resonance search (see **A.14.2.2**) and with the same vibration characteristics. Compare the resonance frequencies and the frequencies that cause significant changes in the output signal found in the initial resonance search and final resonance search.

NOTE Differences are possibly caused by non-elastic deformation leading to the initiation of cracks in the mechanical construction.

A.14.3 *Final measurements.* The good mechanical condition of the transmitter shall be verified at the end of the test.

A.15 Start-up drift test

Carry out the test by measuring the changes that occur in the output in the period immediately following application of the electrical power supply to the transmitter. Prior to the test, subject the transmitter to ambient test conditions (see **A.1.1**) for a period of 24 h without it being energized.

With a 10 % input signal applied to the transmitter, switch it on and measure the output after 5 min, 1 h and 4 h. Then switch the transmitter off, and after at least 24 h under ambient test conditions (see **A.1.1**) repeat the test with a 90 % input signal. The output values obtained show the short-term drift characteristics of the transmitter.

A.16 Long-term drift test

Operate the transmitter for 30 days with a steady input signal corresponding to 90 % of span. Measure the input and output each day and determine the output drift, corrected by calculation for any small variation of input.

NOTE Care should be taken that changes owing to external ambient influences, other than time, do not mask the effects of long-term drift.

Measure the lower-range value and span immediately before and after the 30 days test period.

A.17 Accelerated operational life test

Connect the transmitter up as for normal operation. Apply an initial alternating input with peak to peak amplitude equal to half the span and centred at the mean of the maximum and minimum input values. The frequency shall be such that the peak output signal is not attenuated by more than 20 % of that of the calibrated signal. Subject the transmitter to 1 00 000 cycles as specified above. Measure zero, span, and hysteresis at mid-span before and after the test and note any changes.

A.18 Proof pressure test

Carry out the test using water or some suitable liquid at a pressure equal to 1.5 KP, where

$$K = \frac{Y_1}{Y_2}$$

P is the maximum safe working pressure for which the instrument has been designed

Y_1 is the yield stress of material of the pressure chamber at the temperature of test

Y_2 is the yield stress of the material at the maximum operating temperature for which P applies

NOTE Where more than one material is involved, K refers to the material for which it is greatest. Values of $K \leqslant 1$ are taken as $K = 1$. Yield stress in this context is that stress which produces, on a tensile test piece of the material, a permanent set of 0.1 %, it being assumed that creep does not occur. The maximum operating temperature is taken as the maximum temperature of the fluid in contact with the instrument.

Take adequate steps to remove air from the instrument and the connections to it. Apply the test pressure to both inlet ports simultaneously at a rate that imposes no shock on the instrument.

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Publications referred to

BS 21, *Pipe threads for tubes and fittings where pressure-tight joints are made on the threads.*
BS 2011, *Basic environmental testing procedures.*
BS 2011-2.1A, *Tests A. Cold.*
BS 2011-2.1B, *Tests B. Dry heat.*
BS 2011-2.1Ca, *Test Ca. Damp heat, steady state.*
BS 2011-2.1Ec, *Test Ec. Drop and topple, primarily for equipment-type specimens.*
BS 2011-2.1Fc, *Test Fc. Vibration (sinusoidal).*
BS 4568, *Steel conduit and fittings with metric threads of ISO form for electrical installations.*
BS 2011, *Specification for degrees of protection provided by enclosures.*

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