BRITISH STANDARD

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Incorporating Amendment No. 1

Specification for

Absolute and gauge pressure transmitters with electrical outputs

UDC 621.316.79:531.787:532.11

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Industrial-process Measurement and Control Standards Committee (PCL/-) to Technical Committee PCL/1 upon which the following bodies were represented:

British Gas Corporation
British Industrial Measuring and Control Apparatus Manufacturers' Association (BEAMA)
British Pressure Gauge Manufacturers' Association
Department of Energy, Gas Standards
Electricity Supply Industry in England and Wales
Energy Industries Council
Engineering Equipment and Materials Users' Association
Institution of Gas Engineers
National Coal Board
Scientific Instrument Manufacturers' Association (BEAMA)
STC Water Regulations and Fittings Scheme

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Valve Manufacturers' Association Ltd
Department of Trade and Industry
Department of Trade and Industry, National Physical Laboratory
Department of Trade and Industry, National Engineering Laboratory
Metals Society
Ministry of Defence
Sira Limited

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Contents

Foreword

This British 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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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 absolute and gauge pressure measurement.

This specification applies to transmitters for general industrial use but does not apply to aerospace, marine, laboratory and medical requirements.

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

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
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 the method described in **A.2.2**.

2.2
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 due to dead band may be determined by a conventional dead band test.

2.3
hysteresis error

that portion of hysteresis due 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.

2.4
dead band

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

2.5
range

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

2.6
lower range value

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

2.7
upper range value

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

2.8
span

the algebraic difference between the upper and lower range values

2.9
over-range

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

2.10
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

2.11
transmitter

a measuring transducer whose output is a standardized signal

2.12
absolute pressure

an indication of pressure based on a zero at total vacuum

2.13
gauge pressure

an indication of pressure based on a zero at the ambient atmospheric pressure

3 Classification

3.1 General. The performance characteristics of transmitters are classified as follows:

a) accuracy (see Table 1);

b) temperature coefficient (see Table 2).

The performance characteristics shall be identified by a two-element code in the above order, followed by the range of the transmitter within which the characteristics apply.

Example:

0.5A	0 kPa to 200 kPa absolute (0 bar to 2 bar absolute)[a]
0.5A	0 MPa to 10 MPa gauge (0 bar to 100 bar gauge)

[a] 1 bar = 10^5 N/m^2 = 100 kPa.

3.2 Adjustable range transmitters. For adjustable range transmitters the performance characteristics shall be identified by two-element codes as specified in **3.1** appropriate to ranges corresponding at least to the maximum and minimum spans.

Example:

1)	0.5A	0 kPa to 200 kPa absolute (0 bar to 2 bar absolute)
	1B	0 kPa to 25 kPa absolute (0 bar to 0.25 bar absolute)
2)	0.5A	0 MPa to 10 MPa gauge (0 bar to 100 bar gauge)
	1B	0 MPa to 1 MPa gauge (0 bar to 10 bar gauge)

4 Performance

4.1 General. Reference conditions shall be as given in **A.1**.

4.2 Accuracy. When tested in accordance with the method described in **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.

NOTE 1 For the first 60 min after the power supply is switched on, these requirements do not apply because of the possible effect of start-up drift.

Table 1 — Limits of combined error

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

NOTE 2 The requirements of **4.5.2.2**, **4.5.2.4**, **4.9.3**, **4.11** and **4.12** need to be taken into account in determining the accuracy class given in Table 1.

NOTE 3 The error of a local output current indicator, if fitted, is not included in the calculation of the error of the transmitter.

4.3 Temperature variations

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

4.3.2 *Effect of temperature variations.* The effect of temperature variations shall be tested in accordance with the method described in **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	Limits of residual zero shift and span change
	% of output span per °C	% 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.

4.4 Humidity

4.4.1 *General.* When tested in accordance with the methods described in **A.4** and **A.5** the transmitter shall be capable of continuous operation at a relative humidity up to 95 %.

4.4.2 *Effect of relative humidity variations.* There is no additional requirement 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.

4.5 Electrical characteristics

4.5.1 ***Output circuit***

4.5.1.1 *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.

4.5.1.2 *Ripple and noise.* The peak-to-peak value of internally generated ripple and noise appearing in the output current shall not exceed the value given in Table 1 up to a maximum of 1 % of the output span, in 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.

4.5.1.3 *Stability.* The output of the transmitter shall be stable and the ripple shall comply with **4.5.1.2** when the manufacturers recommended maximum resistive load is shunted by any capacitance up to a maximum of 1 µF.

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

4.5.2 ***Power supply and load***

4.5.2.1 *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 the 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.

4.5.2.2 *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 0.1 % of the output span for accuracy class 0.2, 0.2 % of the output span 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 output.

4.5.2.3 *Supply aberrations.* After supply interruptions are applied to the transmitter under the conditions described in **A.7** the transmitter shall be capable of continuous operation in accordance with **4.2**.

4.5.2.4 *Load resistance.* When the load resistance is varied from zero 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 0.1 % of the output span for accuracy class 0.2, 0.2 % for accuracy classes 0.5, 1 and 2 and 0.5 % for accuracy class 5.

4.5.3 ***Interference***

4.5.3.1 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 the method described in **A.8**, or 1 V 50 Hz in series mode, when tested in accordance with the method described in **A.9** 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 of between 0.5 MΩ and 10 MΩ.

4.5.3.2 When tested in accordance with the method described in **A.10** 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.

4.5.3.3 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.

NOTE 1 No test is specified for this requirement. The manufacturer should be consulted for the appropriate test.

NOTE 2 For the purpose of testing, the output should be set to 50 % of span.

4.6 Pressure

4.6.1 *Over-range pressure.* The pressure transmitter shall be capable of withstanding the over-range pressure given in Table 3. When tested in accordance with the method described in **A.11**, the residual zero shift and span change each shall not exceed one quarter of the values of the limits of error given in Table 1 for the accuracy class of the transmitter.

4.7 *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 **4.2**.

4.8 *Mechanical shock.* Transmitters shall be capable of withstanding mechanical shock of the severity described in **A.12**.

Table 3 — Over-range pressure

Upper range limit	Over-range pressure
MPa (10 bar) Up to 14 (140 bar)	 Upper range limit + 25 % or 150 kPa (1.5 bar) whichever is the greater
14 to 70 (140 bar to 700 bar)	Upper range limit + 15 %
Over 70 (over 700 bar)	Upper range limit + 10 %

4.9 Vibration

4.9.1 *General.* Transmitters shall be capable of withstanding vibration of the severity described in **A.13**. For the test performed with power applied to the transmitter, the input shall be set to 50 % of span.

4.9.2 *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.

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

4.10 Start-up drift. When the transmitter is tested in accordance with **A.14** the difference between the values measured after 5 min and after 60 min shall not exceed 0.2 % of output span.

4.11 Long-term drift. The long-term drift shall be tested in accordance with the method described in **A.15**.

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.

The average long-term drift owing to cumulative errors from all internal sources shall not exceed the values given in Table 4. No individual point shall exceed three times the values given in Table 4 after correcting for ambient influences as described in **A.15**.

Table 4 — Limits of average long-term drift

Accuracy class	Limits of average long-term drift
	% of output span per 30 days
0.2	± 0.075
0.5, 1 and 2	± 0.15
5	± 0.3

4.12 Stability with cycling input. After the transmitter has been subjected to the test described in **A.16** 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.

4.13 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.

5 Materials and construction

5.1 Materials and finishes. Materials and finishes of construction shall be capable of withstanding the limits of influence conditions specified in **4.3**, **4.4** and **4.8**.

5.2 Construction

5.2.1 *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, IP 65, as specified in BS 5490.

5.2.2 *Proof pressure.* The enclosures subject to process 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.

NOTE For low range absolute pressure transmitters having an over-range limit of 150 kPa (1.5 bar) the proof pressure may be applied using any suitable gas.

5.2.3 *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)], or specialized vacuum connections.

5.2.4 *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[1)].

5.2.5 *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 as specified by the manufacturer.

6 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 over-range pressure.

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

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

Annex A Methods of test

A.1 Environmental test conditions

A.1.1 *Ambient conditions for test measurements.* The range of ambient conditions for test measurements should be 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 atmosphere 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 standard reference atmosphere is equivalent to the normal reference operating conditions usually identified by the manufacturer.

NOTE 3 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.

NOTE 4 Suitable atmospheric conditions are given in Table 5 but for tropical, sub-tropical or other special requirements, alternate reference conditions may be used.

Table 5 — 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)	—

A.2 Accuracy related tests

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

State the uncertainty of measurement 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 described in **A.2.1**. Measure output values for each chosen input value and for one full range traverse in each direction.

The input shall be applied in such a way that neither input nor 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 five cycles [steps a) to d)]. Record the maximum value.

Dead band is expressed as a percentage of the 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 deviation from the measured error 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 2011-2.1Ca)

A.4.1 Measure the output under ambient test conditions and maintain the transmitter at ambient test conditions for 24 h. Take a set of reference measurements. Then maintain the transmitter for a period of at least 48 h in a chamber at atmospheric pressure, at a temperature of 40 ± 2 °C, and at a relative 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, 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

NOTE 1 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 changes.

NOTE 2 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

A.7.1 *Principle*. This test is used to determine the behaviour of the instrument on switching from the normal specified supply to a standby supply.

A.7.2 *Procedure*. Hold the input 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 10 times with random phase for each value, the period of time between two tests being at least 10 times the duration of the test.

A.8 Common mode interference test

NOTE 1 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 2 If the manufacturer specifies a value less than 250 V then this lower value should be used instead.

A.9 Series mode interference test

A.9.1 *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.9.2 *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 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.10 Test for transmitters consisting of two or more separate units connected by a screened cable. 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.

A.11 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 given in Table 3.

After the over-range has been applied for 1 min, reduce the input to the nominal lower range value. After a further 5 min have elapsed, determine the output zero and the span.

A.12 Mechanical shock test
(see BS 2011-2.1Ec)

A.12.1 *Principle.* This test is 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.12.2 *Procedure.* Record lower range value and span.

Stand the transmitter in its normal position of 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 to the test surface.

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

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

A.13 Mechanical vibrations test
(see BS 2011-2.1Fc)

A.13.1 *Principle.* This test is used 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.13.2 *Procedure*

A.13.2.1 *Preparation.* 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 of the mounting plate and of 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.13.2.2 *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.13.2.4**).

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 6.

Table 6 — 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.13.2.3 *Second stage: endurance conditioning by sweeping.* Perform the test described in **A.13.2.2** 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 vibration for 2 h in each of the three mutually perpendicular directions.

A.13.2.4 *Third stage: final resonance search.* Carry out the final resonance search in the same way as the initial resonance search (see **A.13.2.2**) and with the same vibration characteristics. Compare the resonance frequencies, and the frequencies which 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.13.3 *Final measurements.* Check that the transmitter is in good mechanical condition at the end of the test.

A.14 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.15 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.

For transmitters with pressure ranges of 250 kPa (2.5 bar) or less, check the long term drift at zero pressure.

NOTE Zero pressure is atmospheric pressure for gauge pressure transmitters, and a suitably high vacuum for absolute pressure transmitters.

A.16 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 100 000 cycles as specified above. Measure zero, span, and hysteresis at mid-span before and after the test and note any changes.

A.17 Proof pressure test. Carry out the test using water or some suitable liquid at a pressure equal to 1.5 *KP*.

Where

- K is a constant and is equal to 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 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 2011-2.1N, *Test N. Change of temperature.*
BS 4568, *Steel conduit and fittings with metric threads of ISO form for electrical installations.*
BS 5490, *Specification for degrees of protection provided by enclosures.*

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