

Methods for

Evaluating the performance of transmitters for use in industrial-process control systems

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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 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
- GAMBICA (BEAMA Ltd.)
- Institution of Gas Engineers
- National Coal Board
- STC Water Regulations and Fittings Scheme

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

- Department of Trade and Industry
- SIRA Ltd.

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Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Introduction	1
1 Scope	1
2 Object	1
3 Definitions	1
4 General testing procedures	2
5 Environmental test conditions	3
6 Static behaviour	4
7 Dynamic behaviour	11
Appendix A Other considerations	20
Appendix B Sample calculations	21
Figure 1 — Schematic diagram of power supply transient overvoltages	16
Figure 2 — Common mode interference	17
Figure 3 — Series mode interference	18
Figure 4 — Flow characteristics of a pneumatic transmitter	18
Figure 5 — Frequency response test results	19
Figure B.1 — Deviation curves	22
Figure B.2 — Hysteresis	22
Table B.I — Sample measurement tabulation	21
Publications referred to	Inside back cover

National foreword

This British Standard has been prepared under the direction of the Industrial-process Measurement and Control Standards Committee. It is identical with IEC Publication 770:1984 “*Methods of evaluating the performance of transmitters for use in industrial-process control systems*”, published by the International Electrotechnical Commission (IEC).

It supersedes BS 4509-1:1969, BS 4509-2:1970 and BS 4509-3:1970 and BS 3512:1962 which are withdrawn.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards.

Wherever page numbers are quoted, they are IEC page numbers.

Cross-references

International Standards	Corresponding British Standards
IEC 68	BS 2011 <i>Basic environmental testing procedures</i>
IEC 68-2-1:1974	Part 2.1A:1977 <i>Tests A. Cold</i> (Identical)
IEC 68-2-2:1974	Part 2.1B:1977 <i>Tests B. Dry heat</i> (Identical)
IEC 68-2-3:1969	Part 2.1Ca:1977 <i>Test Ca. Damp heat, steady state</i> (Identical)
IEC 68-2-6:1982	Part 2.1Fc:1983 <i>Test Fc. Vibration (sinusoidal)</i> (Identical)
IEC 68-2-14:1984	Part 2.1N:1985 <i>Test N. Change of temperature</i> (Identical)
IEC 68-2-31:1969	Part 2.1Ec:1977 <i>Test Ec. Drop and topple, primarily for equipment-type specimens</i> (Identical)
IEC 278:1968	BS 4308:1979 <i>Specification for documentation to be supplied with electronic measuring apparatus</i> (Identical)
IEC 348:1978	BS 4743:1979 <i>Specification for safety requirements for electronic measuring apparatus</i> (Identical)
IEC 381-1:1982	BS 5863 <i>Analogue signals for process control systems</i> Part 1:1984 <i>Specification for direct current signals</i> (Identical)

The Technical Committee has reviewed the provisions of IEC 382, referred to in clause 1 and IEC 160, referred to in clause 5, and has decided that they are acceptable for use in conjunction with this standard.

NOTE *Textual error.* When adopting the text of the International Standard it was noted that IEC 68-2-4 is referred to in 6.2.11. This IEC standard was withdrawn on 1 January 1983 and the error has been reported to IEC in a proposal to amend the text of the International Standard.

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 to iv, pages 1 to 22, 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.

Introduction

The methods of evaluation specified in this standard are intended for use by manufacturers to determine the performance of their products and by users or independent testing establishments to verify manufacturers' performance specifications.

The test conditions in this standard, for example the range of ambient temperatures and power supply, represent those which commonly arise in use. Consequently, the values specified herein shall be used where no other values are specified by the manufacturer.

The tests specified in this standard are not necessarily sufficient for instruments specifically designed for unusually arduous duties. Conversely, a restricted series of tests may be suitable for instruments designed to perform within a more limited range of conditions.

It will be appreciated that the closest communication should be maintained between the manufacturer and the evaluating body. Note shall be taken of the manufacturer's specifications for the instrument when the test programme is being decided, and the manufacturer should be invited to comment on both the test programmes and the results.

1 Scope

This standard is applicable to transmitters which have either a standard electric current output signal or a standard pneumatic output signal in accordance with IEC Publication 381-1: Analogue Signals for Process Control Systems, Part 1: Direct Current Signals, or IEC Publication 382: Analogue Pneumatic Signal for Process Control Systems. The tests detailed herein may be applied to transmitters which have other output signals, provided that due allowance is made for such difference. Transmitters for the measurement of electrochemical properties, such as pH transmitters, are not covered by this standard.

2 Object

This standard is intended to specify uniform methods of test for the evaluation of the performance of transmitters with pneumatic or electric output signals.

When a full evaluation in accordance with this standard is not required, those tests which are required shall be performed and the results reported in accordance with those parts of the standard which are relevant.

3 Definitions

For the purpose of this standard, the following definitions shall apply:

3.1 Conformity

Of a curve, the closeness to which it approximates a specified curve (for example, linear, logarithmic, parabolic, cubic, square root, etc.).

NOTE 1 It is usually measured in terms of non-conformity and expressed as conformity: for example, the maximum deviation between an average curve and a specified curve. The average curve is determined after making two or more full-range traverses in each direction. The value of conformity is referred to the output span unless otherwise stated.

NOTE 2 As a performance specification, conformity may be expressed as independent conformity, terminal-based conformity, or zero-based conformity.

NOTE 3 Linearity is a specific, but often used, case of conformity where the specified curve is a straight line.

3.1.1 conformity, independent

the maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve, so positioned as to minimize the maximum deviation

3.1.2 conformity, terminal-based

the maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve coinciding with the actual characteristic at upper and lower range-values

3.1.3 conformity, zero-based

the maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve so positioned as to coincide with the actual characteristic at the lower range-value and to minimize the maximum deviation

3.2 dead band

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

3.3 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 (see Figure B.2, page 22 and Table B.I).

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.

3.3.1**hysteresis error**

that portion of hysteresis due to energy absorption in the elements of a measuring instrument. Unless otherwise specified it should be determined by subtracting the effect of the dead band from the maximum measured separation between upscale-going and downscale-going indications of the measured variable during a full range traverse

3.4 Range

The region between the limits within which a quantity is measured, received or transmitted; limits are given by stating the lower and upper range-values. Example: 0 Pa, 20 Pa.

NOTE Transmitters may be supplied with manual or automatic means of adjusting the range. As used in this standard the term "range" and the definitions below apply to the characteristics of the transmitter for a specified setting of the adjustment means.

3.4.1**elevated — zero range**

a range in which the zero value of the measured variable is greater than the lower range-value. Example: -10°C , $+30^{\circ}\text{C}$

3.4.2**lower range-value**

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

3.4.3**upper range-value**

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

3.4.4**span**

the algebraic difference between the upper and lower range-values. Example: 16 mA when the range is 4 mA, 20 mA

3.4.5**suppressed — zero range**

a range in which the zero value of the measured variable is less than the lower range-value. Example: 200°C , 500°C

3.4.6**over-range**

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

3.5**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

3.6**transmitter**

a device which responds to a measured variable to produce a standard output signal for transmission which has a prescribed continuous relationship to the value of the measured variable

3.7**zero adjustment**

a means provided in an instrument to cause a parallel shift in the input-output curve

4 General testing procedures**4.1 Selection of ranges for test**

4.1.1 Unless otherwise stated, where the span is adjustable other than to take up manufacturing tolerances, the tests should be carried out with the span adjustment set approximately at the manufacturer's stated minimum and maximum and at an intermediate value.

4.1.2 Unless otherwise stated, where the zero adjustment is adjustable other than to take up manufacturing tolerance, such as devices equipped with means for suppression or elevation of zero, the tests should be carried out with the elevation/suppression adjustment set for its minimal effect, then at its extremes.

If the extent of adjustment is more than twice the maximum span, tests should also be carried out with the adjustment set approximately at the arithmetic mean of the two extreme values of elevation and/or suppression.

NOTE Testing of a transmitter with provision for substantial adjustment of both span and zero in accordance with Sub-clauses 4.1.1 and 4.1.2 may require an impractically large number of tests. Preliminary tests should be conducted to determine the effect of changing span and zero adjustments on the characteristic being measured so that redundant tests can be eliminated from the test programme in cases where the characteristic can be inferred reliably from fewer tests. For example, hysteresis and dead band may not be significantly affected by selection of the lower and upper range-value if the span is held constant, and often may be calculated for different spans from measurements at a single span setting. In any case the report should clearly indicate relevant values of the measured parameters for each setting of the adjustments so that the values of measured error, hysteresis, dead band, etc., are all referenced to the same adjustment of the transmitter.

4.2 Zero and span should be adjusted to make the actual characteristic conform closely to ideal values at the upper and lower range limits before the tests specified in each clause of this standard. When this is done the fact shall be stated in the evaluation report.

4.3 Unless otherwise stated, the test results shall be expressed as percentages of output span.

4.4 When performance characteristics are specified, they shall be tabulated beside the actual test results.

4.5 The limit of error of the measuring systems used for the test shall be stated in the test report and should be smaller than or equal to one-fourth of the stated limit of error of the instrument tested.

4.6 An adequate time, as specified by the manufacturer, shall be allowed after switching on the power supply in order to allow temperature within the transmitter to stabilize. In the absence of manufacturer specification, a period of at least 15 min should be allowed.

4.7 Errors shall be expressed as departure from the input/output relationship specified by the manufacturer.

For example: A “temperature transmitter” may have an output intended to be linear with respect to input e.m.f., or incorporate a network intended to linearize the output with respect to temperature. To determine the error in the first example, the input/output relationship would be e.m.f. to output; in the second example, it would be temperature to output. Although the same test procedure may be applied, the errors shall be assessed differently.

5 Environmental test conditions

Test conditions specified in this standard are in accordance with IEC Publication 160: Standard Atmospheric Conditions for Test Purposes.

5.1 Recommended range of ambient conditions for test measurements

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

The maximum rate of temperature change permissible during any test shall be 1 °C in 10 min. These conditions may be equivalent to normal operating conditions.

5.2 Standard reference atmosphere

Temperature: 20 °C.

Relative humidity: 65 %.

Atmospheric pressure: 1 013 mbar (101.3 kPa).

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.

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

5.3 Standard atmosphere for referee measurements

When correction factors to adjust atmospheric-condition sensitive parameters to their standard 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 following atmospheric conditions are given for referee measurements.

	<i>Nominal value</i>	<i>Tolerance</i>
Temperature:	20 °C	± 2 °C
Relative humidity:	65 %	± 5 %
Atmospheric pressure:	860 mbar (86 kPa) to 1 060 mbar (106 kPa).	

For tropical, sub-tropical, or other special requirement, alternate referee atmospheres are given in IEC Publication 160. This atmosphere is equivalent to the reference operating conditions usually identified by the manufacturer.

5.4 Supply conditions during tests

5.4.1 Reference values

The values specified by the manufacturer.