BS EN 60770-1:2011

BSI Standards Publication

Transmitters for use in industrial-process control systems

Part 1: Methods for performance evaluation

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National foreword

This British Standard is the UK implementation of EN 60770-1:2011. It is identical to IEC 60770-1:2010. It supersedes BS EN 60770-1:1999 which will be withdrawn on 1 Feburary 2014.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/2, Elements of systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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English version

Transmitters for use in industrial-process control systems - Part 1: Methods for performance evaluation

(IEC 60770-1:2010)

Transmetteurs utilisés dans les systèmes de conduite des processus industriels - Partie 1: Méthodes d'évaluation des performances
(CEI 60770-1:2010)

Messumformer für industrielle Prozessleittechnik - Teil 1: Methoden für die Bewertung des Betriebsverhaltens
(IEC 60770-1:2010)

CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 65B/656/CDV, future edition 2 of IEC 60770-1, prepared by SC 65B, Devices & process analysis, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60770-1 on 2011-01-02.

This European Standard supersedes EN 60770-1:1999.

The significant technical change with respect to EN 60770-1:1999 is as follows:

– 4.3 Load conditions: For pneumatic transmitters, load details have been added.

This standard should be read in conjunction with EN 61298-1, EN 61298-2, EN 61298-3 and EN 61298-4.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2011-10-02
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2014-01-02

Annex ZA has been added by CENELEC.

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Endorsement notice

The text of the International Standard IEC 60770-1:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61187:1993	NOTE	Harmonized as EN 61187:1994 (modified).
IEC 61326-1:2005	NOTE	Harmonized as EN 61326-1:2006 (not modified).

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-300	2001	International Electrotechnical Vocabulary - Electrical and electronic measurements and measuring instruments - Part 311: General terms relating to measurements - Part 312: General terms relating to electrical measurements - Part 313: Types of electrical measuring instruments - Part 314: Specific terms according to the type of instrument	-	-
IEC 60068-2-1	2007	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	2007
IEC 60068-2-2	1974	Environmental testing - Part 2: Tests - Tests B: Dry heat	EN 60068-2-2[1) 2)]	1993
IEC 60068-2-31	2008	Environmental testing - Part 2-31: Tests - Test Ec: Rough handling shocks, primarily for equipment-type specimens	EN 60068-2-31	2008
IEC 60381-1	1982	Analogue signals for process control systems - Part 1: Direct current signals	HD 452.1 S1	1984
IEC 60382	1991	Analogue pneumatic signal for process control systems	EN 60382	1993
IEC 60529	2001	Degrees of protection provided by enclosures (IP Code)	-	-
IEC 60770-3	2006	Transmitters for use in industrial-process control systems - Part 3: Methods for performance evaluation of intelligent transmitters	EN 60770-3	2006
IEC 61000-4-2	2008	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009

[1)] EN 60068-2-2 includes supplement(s) A to IEC 60068-2-2.

[2)] EN 60068-2-2 is superseded by EN 60068-2-2:2007, which is based on IEC 60068-2-2:2007.

Publication	Year	Title	EN/HD	Year
IEC 61000-4-3	2006	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	2006
IEC 61000-4-4	2004	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2004
IEC 61000-4-5	2005	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
IEC 61000-4-6	2008	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	2009
IEC 61000-4-8	2009	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	2010
IEC 61000-4-10	1993	Electromagnetic compatibility (EMC) - Part 4-10: Testing and measurement techniques - Damped oscillatory magnetic field immunity test	EN 61000-4-10	1993
IEC 61000-4-11	2004	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	2004
IEC 61000-4-12	2006	Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Ring wave immunity test	EN 61000-4-12	2006
IEC 61000-4-16	1998	Electromagnetic compatibility (EMC) - Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz	EN 61000-4-16	1998
IEC 61010-1	2001	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements	EN 61010-1 + corr. June [3)]	2001 2002
IEC 61032	1997	Protection of persons and equipment by enclosures - Probes for verification	EN 61032	1998
IEC 61298-1	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 1: General considerations	EN 61298-1	2008
IEC 61298-2	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 2: Tests under reference conditions	EN 61298-2	2008

[3)] EN 61010-1 is superseded by EN 61010-1:2010, which is based on IEC 61010-1:2010.

Publication	Year	Title	EN/HD	Year
IEC 61298-3	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 3: Tests for the effects of influence quantitites	EN 61298-3	2008
IEC 61298-4	2008	Process measurement and control devices - General methods and procedures for evaluating performance - Part 4: Evaluation report content	EN 61298-4	2008

CONTENTS

TRANSMITTERS FOR USE IN INDUSTRIAL-PROCESS CONTROL SYSTEMS –

Part 1: Methods for performance evaluation

1 Scope and object

This part of IEC 60770 is applicable to transmitters which have either a standard analogue electric current output signal or a standard pneumatic output analogue signal in accordance with IEC 60381-1 or IEC 60382. The tests detailed herein may be applied to transmitters which have other output signals, provided that due allowance is made for such differences.

For the evaluation of the intelligent transmitters see IEC 60770-3.

For certain types of transmitters where the sensor is an integral part, other specific IEC or ISO standards may need to be consulted (e.g. for chemical analysers, flowmeters, etc.)

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

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 defined 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 should 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 or safety related duties. Conversely, a restricted series of test may be suitable for instruments designed to perform within a more limited range of conditions.

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.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-300:2001, *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:1974, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60381-1:1982, *Analogue signals for process control systems – Part 1: Direct current signals*

IEC 60382:1991, *Analogue pneumatic signal for process control systems*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

IEC 60770-3:2006, *Transmitters for use in industrial-process control systems – Part 3: Methods for performance evaluation of intelligent transmitters*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2008, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-10:2001, *Electromagnetic compatibility (EMC) – Part 4-10: Testing and measurement techniques – Damped oscillatory magnetic field immunity test*

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-12:2006, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-16:2002, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61298-1:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 1: General considerations*

IEC 61298-2:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 2: Tests under reference conditions*

IEC 61298-3:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 3: Tests for the effects of influence quantities*

IEC 61298-4:2008, *Process measurement and control devices – General methods and procedures for evaluating performance – Part 4: Evaluation report content*

3 Terms and definitions

For the purposes of this part of IEC 60770, definitions given in IEC 60050-300 and in IEC 61298-1 are applicable.

4 General conditions for tests

4.1 Overview

For the purpose of this standard, the general test conditions (e.g. environmental test conditions, supply conditions, load conditions, mounting position, externally induced vibrations, external mechanical constraints, constancy of the operating conditions and settings, input variable quality, delivery of the transmitter, etc.) specified in IEC 61298-1 apply, together with the additional information below.

NOTE It is desirable that the closest communication should be maintained between the manufacturer and the evaluating body. The manufacturer's specifications for the instrument should be taken into account when the test programme is being decided, and the manufacturer should be invited to comment on both the test programmes and the results.

4.2 Supply conditions

For the two-wire transmitters, the normal supply voltage might be 24 V d.c. For pneumatic transmitters, the normal pressure supply might be 140 kPa (1,4 bar).

Tolerances on supply conditions, as given in IEC 61298-1, are not applicable to transmitters with self-contained power supplies (e.g. battery-powered). The tolerance for battery-powered equipment shall be agreed.

4.3 Load conditions

The value of the load to be used shall be agreed. A load of 250 Ω is a commonly used value for electrical transmitters. For pneumatic transmitters, unless otherwise specified, a test load consisting of an 8 m long rigid pipe with a 4 mm internal diameter, followed by a 20 cm^3 capacity (or more), shall be used. Care should be taken to ensure that pneumatic connections are leak-tight.

4.4 Input variable quality

For transmitters that are to be evaluated with an integral sensor, the conditions and requirements for maintaining the quantities to be measured (physical/chemical) shall be properly stated (e.g. for flow transmitters, the fluid through the measuring device shall be that specified by the manufacturer; the temperature of the fluid shall be maintained within ±2 °C of the value specified in order to ensure the correct values of density and viscosity).

5 Analysis and classification of transmitter performance

In determining the test programme and test values to be used in the evaluation, the physical and functional design of transmitter should be taken into account.

Guidance on this process can be found in Annex A.

6 General testing procedures and precautions

For the purpose of this standard, the general testing procedures and precautions (e.g. identification and inspection, preparation for the tests, uncertainty of the measuring system, traceability, tapping, setting of adjustments, preconditioning, sequence of tests, interruption and duration of each series of measurements, anomalies and failures during tests, re-start of a test, input/output variable relationships, error assessment, symbols and units of measurement, etc.) specified in IEC 61298-1 shall be applied. The instrument shall be calibrated by the manufacturer and tested without recalibration. Then additional measurements should be made at the lowest and highest possible span and the remainder of the tests should be carried out at the mean value.

7 Test procedures and reporting

The tests given in Tables 1, 2 and 3 are suitable for industrial process transmitters. If a full evaluation is planned, each applicable test should be conducted. The results should be reported as a percentage of the output span. Unexpected events, including faults and malfunctions, shall be reported.

The test procedures and precautions are described in detail in IEC 61298-2 and IEC 61298-3.

Table 1 – Tests for all transmitters

Designation	Notes on test methods and on information to be reported	Reference	Additional information
Accuracy-related factors			
• Checking of calibration made prior to delivery		IEC 61298-2	
• Inaccuracy and measured error	Three to five upscale and downscale full-range traverses, measuring at least six points along the scale every nearly 20 %. Compute errors and plot error curves	IEC 61298-2	[1] [2]
• Non-linearity		IEC 61298-2	
• Non-conformity		IEC 61298-2	
• Hysteresis		IEC 61298-2	
• Non-repeatability		IEC 61298-2	
• Dead band	Vary input to obtain detectable output change at 10 %, 50 %, 90 % output. Report the maximum variation of input in % of input span	IEC 61298-2	[3]
• Frequency response	Apply peak-to-peak amplitude of 20 % of the input span at frequencies required in order to vary dynamic gain from 1 to 0,1 Plot against frequency – the gain relative to zero frequency gain; – the phase lag between the output and input	IEC 61298-2	[4]
• Step response	Input steps corresponding to 80 % and 10 % of output span. Record the step response time and also the time for the output to reach and remain within 1 % of output span of its steady value (settling time)	IEC 61298-2	
• Start-up drift	Output monitored for 4 h after power is switched on	IEC 61298-2	

Designation	Notes on test methods and on information to be reported	Reference	Additional information
• Long-term drift	Output monitored for 30 days with an input of 90 % of the span	IEC 61298-2	[5]
Effects of influence quantities			
• Ambient temperature	Two or three cycles of the temperature range specified	IEC 61298-3	[6]
• Humidity	One cycle at 40 °C; 93 % HR	IEC 61298-3	
• Vibration (sinusoidal)	Initial resonance search, endurance conditioning over 60 sweep cycles, and final resonance search	IEC 61298-3	
• Shock	"Drop and topple" procedure in accordance with IEC 60068-2-31	IEC 61298-3	
• Mounting position	±10° inclination in two ortogonal planes	IEC 61298-3	[7]
• Overrange	Overrange of 50% of the sensor upper range limit for 1 min. Measure 5 min after return to a value within the normal range For differential pressure transmitters, carry out with the line pressure on both of the inputs in turn	IEC 61298-3	
• Temperature of process fluid	Steady-state changes at 10 % and 90 % of the input span	IEC 61298-3	Only when effect is significant
• Flow of process fluid through the transmitter (other than flow transmitter)	Change of output at 10 % and 90 % of the input span	IEC 61298-3	Only if applicable, e.g. when for normal operation process fluid flows through part of the transmitter
• Static line pressure effect	Change of output at 10 % and 90 % of the input span at each 25 % increment of the static pressure, if applicable. Where not applicable the test shall be performed at least measuring the change of output 0 for 0 differential pressure input	IEC 61298-3	Only for differential pressure transmitters
• Flow of purge gas through the transmitter	Change at 10 % and 90 % of the output with purge flow to 0 %, 50 % and 100 % of the maximum specified (if applicable)	IEC 61298-3	
• Accelerated life	100 000 cycles of amplitude equal to half the span. Measure lower range value, span and hysteresis at start and finish of test. Additional measurements during the test may be required if wear or ageing is anticipated	IEC 61298-3	

[1] For transmitters with analogue output, which include smart options, the adjustment of zero and span can be obtained either locally or by remote device (e.g. computer, hand terminal). These instruments may be equipped with facilities for “blind calibration”. In this case no accurate test device is needed for the adjustment of zero and span.

For this type of transmitter, some manufacturers specify also the inaccuracy of the transmitter after the blind calibration. This type of inaccuracy may differ from the inaccuracy of an instrument calibrated against a standard test device. It can be considered as a new function to be evaluated.

[2] For the purpose of this test and unless otherwise specified for a particular type of transmitter, the measurement cycles shall be at least three but preferably five and the test points six (0 %, 20 %, 40 %, 60 %, 80 %, 100 % input span) or eleven (0 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 80 %, 90 %, 100 % input span). For instruments with a non-linear input-output relationship (e.g. square law), the test points should be chosen so as to obtain output values equally distributed over the output span.

[3] Unless the dead band is known to be insignificant, it shall be measured at 10 %, 50 % and 90 % of the span, proceeding as follows:

a) set the input at the first test point (e.g. 10 %);

b) note the input value;

c) slowly increase the input variable to the transmitter until a detectable output change is observed;

Designation	Notes on test methods and on information to be reported	Reference	Additional information
d) note the input value and repeat the operation in the opposite direction as specified in IEC 61298-2. The increment through which the input signal is varied (difference between d) and b) above), is the dead band at this point. Repeat steps c) and d), slowly increasing the input again until a detectable output change is observed and noting the input value: the increments shall be observed and recorded at least three times, and preferably five times, at each of three test points close to 10 %, 50 % and 90 % of the span, over a full-range traverse. This procedure shall be repeated, at each of the three test points (close to 90 %, 50 % and 10 % of span), decreasing the input variable starting from 90 % of the span. [4] If it is not practicable to generate a sinusoidal signal to be applied to the input of certain transmitters, (flow, integrally mounted sensor transmitters, etc.) this test should not be performed. For pneumatic transmitters, unless otherwise specified, a test load consisting of an 8 m long rigid pipe with a 4 mm internal diameter, followed by a 20 cm^3 capacity, shall be used. Lower amplitudes may be necessary to investigate the full bandwidth capability. [5] Where practicable, the data should be measured each day and processed to determine a best fit straight line and verify if there is a drift in one direction or a random drift. [6] For further information on test temperature procedures, see IEC 60068-2-1 and IEC 60068-2-2. [7] For pressure transmitters the test shall be executed on the two ortogonal planes of the primary pressure element with ±180° respect nominal mounting position or within the limits specified by the manufacturer.			

Table 2 – Additional tests for electrically powered transmitters

Designation	Notes on test methods and on information to be reported	Reference	Additional information
Input resistance of a transmitter with electrical inputs	Resistance presented to d.c. input signals at the input terminals, expressed in Ω	IEC 61298-2	[1]
Insulation resistance	Insulation resistance to earth or to the case of each circuit at 500 V d.c. for 30 s, expressed in Ω	IEC 61298-2	
Dielectric strength	The r.m.s. test voltage (mains frequency) specified shall not result in breakdown or flashover	IEC 61298-2	
Power consumption	Load at maximum supply voltage and minimum frequency specified by manufacturer (in W and VA)	IEC 61298-2	
Output ripple	Peak-to-peak values and principle frequency components	IEC 61298-2	
Output load	Vary load resistance from minimum to maximum as specified by manufacturer	IEC 61298-3	[2]
Source impedance	Vary input circuit resistance from minimum to maximum values specified by manufacturer		[3]
Supply voltage and frequency variations	Nine sets of measurements for variations in a.c. voltage and frequency For transmitters using a d.c. mains supply, three sets are required For two-wire transmitters (loop powered) measure the minimum voltage that is required to sustain the 20 mA output current	IEC 61298-3	[4]
Supply voltage depressions	At 75 % of nominal supply voltage for 5 s. Report the effect on the output signal and its duration. Voltage dips for up to 100 ms may also need to be investigated	IEC 61298-3	[4]

Designation	Notes on test methods and on information to be reported	Reference	Additional information
Short-term supply voltage interruptions	Repeated interruptions at crossover point of 1, 5, 10, 25 cycles for a.c. supply; 5, 20, 100, 200 and 500 ms for d.c. supply. Report the peak positive and negative and the time required to stabilise	IEC 61298-3	[4] [5]
Reverse supply voltage protection		IEC 61298-3	
Common mode interference	For transmitters with terminals isolated from earth 250 V r.m.s., a.c. at mains frequency superimposed on isolated terminals Then positive and negative 50 V d.c. superimposed on isolated terminals	IEC 61298-3	[6]
Normal mode interference (series mode)	1 V or less, at mains frequency and 10 % and 90 % of the output span	IEC 61298-3	
Earthing	Only for transmitters with isolated terminals. Record transients and changes of output	IEC 61298-3	
Electrical fast transients (bursts)	Test voltage specified or 2 kV peak	IEC 61298-3	[7]
Surge voltage immunity	Test voltage specified in the product standard or by user. Commonly used maximum values are 2 kV peak (asymmetric) and 1 kV peak (symmetric)	IEC 61298-3	[8]
Damped oscillatory waves	Test voltage specified or 0,5 kV peak at 1 MHz		[9]
Conducted sine-wave RF-disturbances	Test voltage specified or 10 V r.m.s. from 0,15 MHz to 80 MHz		[10]
Electrostatic discharge	Test voltage specified or 6 kV (contact), 8 kV (air)	IEC 61298-3	[11]
Power frequency magnetic field	Continuous: 100 A/m (unless higher values are agreed) at 10 % and 90 % of the output span Short duration: 400 A/m for 1 s at 50 % output span	IEC 61298-3	[12]
Damped oscillatory magnetic field	Value of field specified or 30 A/m at 0,1 MHz and 1,0 MHz		[13]
Radiated, radio-frequency electromagnetic field	Value of field specified or 10 V/m from 80 MHz to 1 GHz	IEC 61298-3	[14]
Open and short-circuit of input	Interrupt each input connection and then short together. Report times for the output to recover after removal of open circuit and short-circuit	IEC 61298-3	
Open and short-circuit of output	Interrupt each output connection and then short together. Report times for the output to recover after removal of open circuit and short-circuit	IEC 61298-3	

Designation	Notes on test methods and on information to be reported	Reference	Additional information

[1] The test shall be carried out on the powered transmitter.

[2] If no values are specified, the output load for milliampere outputs shall be varied gradually from short circuit to open circuit and for volt outputs shall be varied from open circuit to short circuit.

[3] On transmitters, the input to which is an electrical voltage, the change in output caused by varying the resistance in the test input circuit from the minimum value specified by the manufacturer to the maximum value shall be measured. The resistance shall be distributed equally in each line (input terminal).

[4] Refer also to IEC 61000-4-11.

[5] For smart transmitters with analogue output, the effect of the supply voltage interruptions on the output may depend on the point in the cycle of the transmitter at which the interruption occurs.

[6] Refer also to IEC 61000-4-16.

[7] Refer also to IEC 61000-4-4.

[8] Refer also to IEC 61000-4-5.

[9] This test shall be performed in accordance with the requirements of IEC 61000-4-12 at a test voltage specified by the manufacturer or at 1 kV peak (common mode) with frequency of 1 MHz; the test shall be repeated with a frequency of 0,1 MHz.

The input level of the transmitters shall be held at a value which produces 50 % output signal.

The damped oscillatory waves are induced by means of a coupling network defined in IEC 61000-4-12.

During the test, any changes in output due to burst disturbance shall be recorded, as well as any damage caused to the transmitter.

[10] This test shall be performed in accordance with the requirements of IEC 61000-4-6 at a test voltage level specified by the manufacturer or at 10 V r.m.s. unmodulated with frequency from 0,15 MHz to 80 MHz.

The input level of the transmitter shall be held at a value which produces 50 % output signal.

The conducted sine-wave RF-disturbances are induced by means of a coupling and decoupling network defined in IEC 61000-4-6.

During the test, any changes in output due to RF-disturbances shall be recorded, as well as any damage caused to the transmitter.

[11] Refer also to IEC 61000-4-2.

[12] Refer also to IEC 61000-4-8.

[13] The transmitter shall be exposed to a damped oscillatory magnetic field of 30 A/m (peak) with oscillation frequencies of 0,1 MHz and 1,0 MHz or at a value specified by the manufacturer; the damped oscillatory magnetic field shall be directed along the major axis of the transmitter.

The test shall be conducted at 10 % and 90 % of the input span. The changes shall be calculated and reported as a percentage of the output span. The effect of the field on the ripple content of the output shall be determined.

The test shall be repeated with the magnetic field directed along two additional axes mutually perpendicular and perpendicular to the first.

For further consideration, refer to IEC 61000-4-10.

[14] For further consideration, refer to IEC 61000-4-3.

Table 3 – Additional tests for pneumatic transmitters

Designation	Notes on test methods and on information to be reported	Reference	Additional information
Air consumption	Record the input which produces the maximum air consumption in m³/h (at reference conditions of 0 °C and 101,3 kPa)	IEC 61298-2	
Output load	Air bled from/into transmitter with input set at 10 %, 50 %, and 90 % of the span. See Figure 5 of IEC 61298-2	IEC 61298-3	
Air supply pressure variations	Nominal reference supply pressure varied from +10 % to –15 %	IEC 61298-3	
Air supply pressure interruptions	Interruptions of the supply for 1 min at 90 % input. Report time to recover after the re-application of the supply	IEC 61298-3	

8 Other considerations

8.1 General

Additional tests may be carried out in order to verify some other characteristics of the transmitter, such as the safety and degree of protection provided by the enclosure.

In order to prepare the general information required for the test report, procedures for

- installation,
- routine maintenance and adjustment,
- repairs and overhaul,

shall be examined through the actual performance of the required operations. This shall be performed in accordance with the manufacturer's instructions, so that an evaluation of the instructions can be carried out concurrently.

8.2 Safety

Electrically powered transmitters shall be examined to determine the degree to which its design protects against accidental electric shock (see IEC 61010-1).

8.3 Degree of protection provided by enclosure

If requested, tests shall be made in accordance with IEC 60529 and IEC 61032.

8.4 **Documentary information** (see IEC 61187)

All the relevant publications supplied by the manufacturer, automatically and on request, shall be listed.

If they do not contain a clear description of the operation of the transmitter, together with adequate diagrams, or, if they do not contain an adequate parts list and specification, the nature of the inadequacy shall be stated.

Additionally, any certificates indicating the degree of intrinsic safety and flame-proofing, etc. of electrically powered transmitters shall be listed.

This information shall give details of the certificate numbers and the degree of protection provided.

8.5 Installation

The transmitter shall be installed and set to work according to the manufacturer's instructions. The choice of installation tested shall take account of the various applications which may be met in practice and which require differing procedures.

The method of mounting specified by the manufacturer should be reported. Any restrictions on the use of the transmitter caused by this method of mounting shall be stated with explanations.

Any other aspects that are considered relevant to the ease or difficulty of installation shall be stated with explanations.

8.6 Routine maintenance and adjustment

The operations considered necessary for routine maintenance and adjustment shall be carried out in accordance with the manufacturer's instructions.

Any aspects that are relevant to the ease or difficulty experienced in order to perform these operations shall be stated, giving reasons.

8.7 Repair

It is usual for transmitters to be capable of division into a number of subassemblies and for manufacturers to detail repair procedures in terms of the removal and replacement of such subassemblies. These subassemblies may be suitable for further dismantling by users. To assess the ease with which repairs may be carried out, the subassemblies should be removed one at a time, each being dismantled to the extent that is permissible according to the manufacturer’s instructions.

Any aspects which are relevant to the ease or difficulty experienced in order to perform these repairs shall be stated, giving reasons.

8.8 Protective finishes

The protective finishes on external parts specified by the manufacturer shall be listed with relevant comments.

8.9 Design features

Any aspects of design or construction likely to cause difficulties in use shall be listed with reasons. So also should any features which appear to be of particular interest, for example, the degree of enclosure of the working parts, interchangeability of spares and weatherproofing.

8.10 Variants

Important variants or options listed by the suppliers shall be described in the report.

8.11 Tools and equipment

Tools and equipment essential to the installation, maintenance and repair shall be listed.

9 Test report and documentation

A complete test report of the evaluation shall be prepared in accordance with IEC 61298-4 after the completion of the tests.

All the original documentation related to the measurements made during the tests shall be stored by the test laboratory for at least two years after the report is issued.

Annex A
(informative)

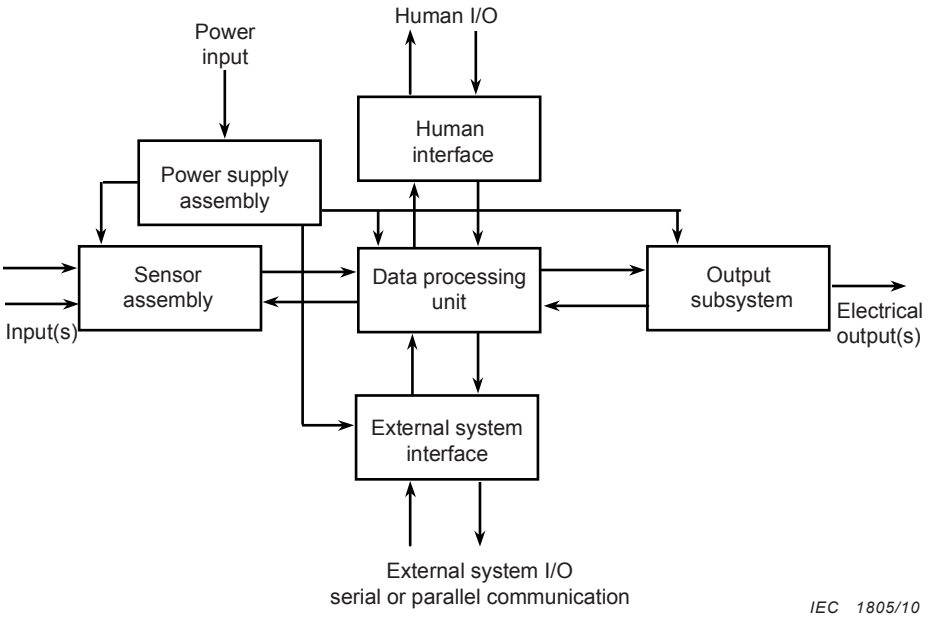
Analysis and classification of the instrument performance

A.1 Instrument model

A.1.1 General

The actual implementation of an instrument evaluation should be preceded by a structured analysis of the physical and functional design of the instrument concerned. This analysis, together with the requirements stated by the user, should lead to definition of the (transfer) functions and properties to be evaluated.

These considerations are guided and facilitated by the following generic instrument model and its description. The model block diagram shows the basic modules (building blocks) that can be distinguished in a maximum configuration.



NOTE If the external system is present, see IEC 60770-3.

Figure A.1 – Instrument model

A.1.2 Sensor assembly

The sensor assembly converts the main input signal and possible auxiliary inputs into electrical signals which are fed into the data processing unit.

The sensor assembly may be integrated with the other modules in one enclosure. It can also be located remotely (in the case of a densitometer, electromagnetic flow meter, thermocouple transmitter). Depending on the measurement principle used, the sensor assembly may not require auxiliary (external) power (such as with thermocouples) or, it may require auxiliary

power (strain gauges or resistance temperature detectors) or, a specifically characterized power source (such as in electromagnetic and Coriolis-type mass flowmeters).

Since it is in contact with the process medium, the sensor assembly may be influenced by medium properties and conditions and by installation conditions. As a remote unit it may also be subjected to more severe environmental conditions. It should also be considered whether it is necessary to apply combined environmental and process conditions during an evaluation.

Sensor assemblies can have sensors of different nature (such as auxiliary for compensation or diagnostic purposes). For each sensor a suitable measurement arrangement will be required.

A.1.3 Data processing unit

The data processing unit may use either analogue, digital (microprocessor-based) techniques or a combination. Its main function is processing (analogue-to-digital conversion, linearization, characterization, alarm detection, etc.) and controlling the sensor signals, and providing the processed and/or standardized signals to the (electrical) output subsystem. The signals will be either continuous (in analogue instruments) or periodical (in microprocessor-based instruments). Moreover, it provides these data to the human interface and the external system interface and/or receives data from these interfaces.

Microprocessor-based instruments may be equipped with self-diagnostic software and diagnostic sensors for automatically maintaining integrity and shall be evaluated according to IEC 60770-3.

A.1.4 Output subsystem

The output subsystem provides standardized analogue electrical output signals (mA, V, frequency or pulse train) or binary (contact, solid state) output signals that can be used by remote equipment for process control. For microprocessor-based instruments, the output subsystem will be provided with a digital-to-analogue converter if analogue output signals are requested.

A.1.5 Human interface

The human interface provides means for observing the process variables, manipulating and adjusting certain parameters. In simple instruments it may only be a numeric display or an analogue indicator. In more complex instruments it may be a fixed or plug-in type keyboard/display unit for read-out and access. It may sometimes also provide means for by-passing sensor signals and direct adjustment of the output in the event of a detected sensor failure. In this model jumpers and adjustment potentiometers for zero, span or linearity are also considered to be a part of the human interface.

A.1.6 External system interface

The external system interface (for instance a fieldbus) provides means for either parallel or serial communication to a data acquisition system, a distributed control system, a SCADA-system (Supervisory Control And Data Acquisition system) or a hand terminal for local read-outs. Communication through this interface may be bidirectional.

A.1.7 Power supply assembly

The power supply assembly receives either an unregulated a.c. or d.c. supply signal. It provides stabilized and regulated supply voltages and/or currents (either a.c. or d.c. or a combination) to the various parts of the instrument.

A.2 Instrument classification

The model referenced by Figure A.1 can be used to describe the following types of instruments and for identifying their modules.

In this summary, (--) stands for any physical, electrical or chemical quantity to be measured and processed, such as pressure, temperature, level, flow rate, density, pH, composition, as reported below:

a) (--) transmitter — a measuring transducer whose output is a standardized signal

b) (--) meter — an instrument intended to measure a physical quantity

c) (--) indicator — an instrument intended to visually indicate a physical quantity

d) (--) switch — a measuring transducer whose output is a binary signal (ON/OFF or 0/I)

e) (--) transducer — a device which accepts information in the form of a physical quantity and converts it into information in the form of the same or another physical quantity according to a definite law

f) (--) sensor — an electric signal transducer that converts a signal of any kind into an electric signal

Instruments that are to be evaluated do not always comprise all modules shown in this model (see Figure A.1).

EXAMPLES

– Indicators in general do not have an (electrical) output subsystem; their data processing units provide signals to a human interface (analogue or digital display) only.

– Many instruments are still not provided with an external system interface.

– Many temperature transmitters for thermocouples or resistance temperature detectors are not provided with the sensor assembly.

For evaluation tests a suitable simulation in accordance with the appropriate tables may be used. It is clear that in such a case it is not relevant to define process medium properties and conditions as influencing (test) conditions for these instruments.

Before defining an evaluation test programme, the instrument under consideration should be analysed along the lines of the model (see Figure A.1). In the analysis it may also be decided that the transfer function of a single block shall be considered as a separate entity. It is however only relevant when its input signal can be influenced (adjusted) independently and its output signal be measured externally.

In many cases the data processing unit and the output subsystem are fully integrated and the intermediate signals cannot be made accessible. In that case, the definition and consideration of the separate transfer functions are not relevant.

A.3 Instrument functions

The instrument functions to be considered are in fact the (mathematical) transfer functions that are characteristic for, or can be defined in the various blocks or combination of blocks as shown in the block diagram of Figure A.1. The following transfer functions may be considered:

– input to sensor output;
– input or sensor output to electrical output (mA, V, contact, etc.);
– input or sensor output to human interface output (displayed value);
– input or sensor output to external system interface;
– human interface to output;
– external system to output and/or to human interface;
– human interface to external system interface.

It is also important to determine whether the characteristic input-to-sensor function is linear, logarithmic, quadratic or has any other form. When linearization is provided in another block, this may also have to be considered. A thermocouple-input forms an example where the sensor provides a non-linear voltage signal that is, either by electronic circuits or by software, again made temperature-linear at the analogue output.

Auxiliary and diagnostic transfer functions may be treated in a similar way.

It should be realized that the number of transfer functions defined which require an evaluation has an impact on the time and costs required for an evaluation.

A.4 Considerations on measuring the instrument performance

The facilities introducing the physical quantity in an accurate and traceable way in absolute values to the instrument during an evaluation are an important issue. Extensive equipment may be required in which all factors influencing the quantity to be applied as an input to the Device Under Test (DUT) are sufficiently controlled. This equipment may not be portable and certain tests (for instance vibration, ambient temperature tests) may become extremely expensive. It shall be considered whether this equipment is necessary for all these tests. Except for the accuracy measurements, the tests often require only stable and accurately adjustable signals, and it may be decided to perform these tests with facilities fulfilling only these requirements.

When measuring a full calibration curve becomes economically unfeasible, it may be decided to perform measurements at "zero-input" and/or 100 % input or with an arbitrary input. This reduction to zero and 100 % (span) measurements only is solely permitted when the I/O-characteristic of the DUT is linear. In the worst case it may have to be decided to skip a test.

For instruments that are not equipped with a sensor assembly (such as thermocouple- and resistance temperature detectors-transmitters) an electric simulation following standardized tables or agreed values replaces the sensor assembly.

The instrument may also be equipped with an auxiliary digital input circuit which is essential in certain applications. If so it may also be decided to consider it for the evaluation.

The uncertainty of the facilities and the measuring equipment used may have to be determined.

Bibliography

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IEC 61187:1993, *Electrical and electronic measuring equipment – Documentation*

IEC 61326-1:2005, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

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