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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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Transmetteurs utilisés dans les systèmes de conduite des processus industriels – Partie 1: Méthodes d'évaluation des performances

IEC 60770-1:2010
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TRANSMITTERS FOR USE IN INDUSTRIAL-PROCESS CONTROL SYSTEMS –

Part 1: Methods for performance evaluation

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International Standard IEC 60770-1 has been prepared by subcommittee 65B: Devices & process analysis, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 1999. This edition constitutes a technical revision.

The significant technical change with respect to the previous edition is as follows:

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

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

The text of this standard is based on the following documents:

CDV	Report on voting
65B/656/CDV	65B/720/CDV

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 60770 series, published under the general title *Transmitters for use in industrial-process control systems*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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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.

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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.

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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*

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

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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.

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4.2 Supply conditions

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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	

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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;

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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

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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	

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