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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Process measurement and control devices – General methods and procedures for evaluating performance –
Part 2: Tests under reference conditions

Dispositifs de mesure et de commande de processus – Méthodes et procédures générales d'évaluation des performances –
Partie 2: Essais dans les conditions de référence

IEC 61298-2:2008

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PROCESS MEASUREMENT AND CONTROL DEVICES – GENERAL METHODS AND PROCEDURES FOR EVALUATING PERFORMANCE –

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61298-2 has been prepared by subcommittee 65B: Devices and process analysis, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 1995 and constitutes a technical revision.

This edition is a general revision with respect to the previous edition and does not include any significant changes (see Introduction).

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

FDIS	Report on voting
65B/686/FDIS	65B/694/RVD

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 the IEC 61298 series, under the general title *Process measurement and control devices – General methods and procedures for evaluating performance*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This standard is not intended as a substitute for existing standards, but is rather intended as a reference document for any future standards developed within the IEC or other standards organizations, concerning the evaluation of process instrumentation. Any revision of existing standards should take this standard into account.

This common standardized basis should be utilised for the preparation of future relevant standards, as follows:

– any test method or procedure, already treated in this standard, should be specified and described in the new standard by referring to the corresponding clause of this standard. Consequently new editions of this standard are revised without any change in numbering and scope of each clause;

– any particular method or procedure, not covered by this standard, should be developed and specified in the new standard in accordance with the criteria, as far as they are applicable, stated in this standard;

– any conceptual or significant deviation from the content of this standard, should be clearly identified and justified if introduced in a new standard.

PROCESS MEASUREMENT AND CONTROL DEVICES – GENERAL METHODS AND PROCEDURES FOR EVALUATING PERFORMANCE –

Part 2: Tests under reference conditions

1 Scope

This part of IEC 61298 specifies general methods and procedures for conducting tests and reporting on the functional and performance characteristics of process measurement and control devices. The tests are applicable to any such devices characterized by their own specific input and output variables, and by the specific relationship (transfer function) between the inputs and outputs, and include analogue and digital devices. For devices that require special tests, this standard should be used, together with any product specific standard specifying special tests.

This standard covers tests made under reference conditions.

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, *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments (composed of Part 311, 312, 313 and 314)*

IEC 60050-351, *International Electrotechnical Vocabulary (IEV) – Part 351 : Control technology*

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

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

3 Terms and definitions

For the purpose of this document, the following relevant terms and definitions, some of them based on IEC 60050(300) or IEC 60050(351), apply.

3.1
variable
quantity or condition whose value is subject to change and can usually be measured (e.g., temperature, flow rate, speed, signal, etc.)
[IEV 351-21-01, modified]

3.2
signal
physical quantity, one or more parameters of which carry information about one or more variables which the signal represents
[IEV 351-21-51, modified]

3.3
range
range of values defined by the two extreme values within which a variable can be measured within the specified accuracy
[IEV 351-27-11, modified]

3.4
span
algebraic difference between the values of the upper and lower limits of the measuring range
[IEV 311-03-13]

3.5
inaccuracy
maximum positive and negative deviation from the specified characteristic curve observed in testing a device under specified conditions and by a specified procedure

NOTE 1 Accuracy is defined in IEC 60050-300, definition 311-06-08.

NOTE 2 The term inaccuracy is sometime referred to as measured accuracy. This term should not be used.

3.6
error
algebraic difference between the indicated value and a comparison value of the measured variable
[IEV 351-27-04, modified]

NOTE The error is positive when the indicated value is greater than the comparison value. The error is generally expressed as a percentage of the relevant ideal span.

3.7
measured error
largest positive or negative value of errors of the average upscale or downscale values at each point of measurement

3.8
non-conformity
the closeness with which a calibration curve approximates to a specified characteristic curve (which can be linear, logarithmic, parabolic, etc.)

NOTE Non-conformity does not include hysteresis.

3.9
non-linearity
deviation from linearity

NOTE 1 Linearity is defined in IEC 60050(300), definition 311-06-05.

NOTE 2 Non-linearity does not include hysteresis.

3.10
non-repeatability
deviation from repeatability

NOTE Repeatability is defined in IEC 60050(300), definition 311-06-06.

3.11
hysteresis
property of a device or instrument whereby it gives different output values in relation to its input values depending on the directional sequence in which the input values have been applied
[IEV 351-24-15, modified]

3.12
dead band
finite range of values within which a variation of the input variable does not produce any measurable change in the output variable
[IEV 351-24-14, modified]

3.13
dead-time
time interval between the instant when a variation of an input variable is produced, and the instant when the subsequent variation of the output variable starts
[IEV 351-28-41]

(see IEC 60050-351, Figure 5)

3.14
rise time
for a step response, the duration of the time interval between the instant when the output variable (starting from zero) reaches a small specified percentage (for instance 10 %) of the final steady-state value, and the instant when it reaches for the first time a large specified percentage (for instance 90 %) of the same difference
[IEV 394-39-11, modified]

(see IEC 60050-351, Figure 3)

3.15
settling time

time interval between the instant of the step change of an input variable, and the instant when the output variable does not deviate by more than a specified tolerance from its final steady state value (see IEC 60050-351, Figure 3). For this standard, a tolerance of 1 % is adopted
[IEV 351-24-29]

3.16
step response time
time interval between the instant of a step change in the input variable and the instant when the output variable reaches for the first time a specified percentage of the difference between the final and the initial steady state value (see IEC 60050-351, Figure 3). For this standard , a specified percentage of 90 % is adopted
[IEV 351-24-28]

3.17
time constant
time required to complete 63,2 % of the total change of the output of a first-order linear system, produced by a step variation of the input variable
[IEV 351-24-24]

3.18
test procedure
statement of the tests to be carried out, and the conditions for each test, agreed between the manufacturer, the test laboratory, and the purchaser/user before the evaluation starts

3.19
type tests
a test of one or more devices made to a certain design to show that the design meets certain specifications

NOTE The type tests are in principle applied only on a sample. Normally are not repeated on all the individual units of equipment made in series.

3.20
performance evaluation
a complete test to establish the performance of a device under any likely operating conditions to permit comparison with the manufacturer's published or stated performance specification for the device, or the user's requirements

3.21
routine test
a simplified test to which each individual instrument is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.22
sample test
a simplified test to check specific characteristics of a device

4 Accuracy related factors

4.1 Test procedures and precautions

4.1.1 Selection of ranges for test

Where there are switched ranges or dial settings (e.g., gain), the tests shall be repeated to cover all ranges or settings. When the Device Under Test (DUT) is supplied calibrated for use, the first set of tests shall be carried out without adjustment.

4.1.1.1 Criteria

The measurements shall be performed with the devices operating at the minimum number of calibration settings necessary to establish the device performance in all required operational settings required by the test programme (see Clause 5 of IEC 61298-1).

Testing of a device which has provision for substantial adjustment of both span and lower range value may require an impractically large number of tests. In such a case, preliminary tests shall be conducted to determine the effect of changing span and lower range value adjustments on the characteristic being measured. This should enable some tests to be eliminated from the test programme in cases where the characteristic can be inferred reliably from fewer tests. For example, hysteresis may not be significantly affected by selection of the lower and upper range value if the span is held constant, and often may be inferred for different spans from measurements at a single span setting.

However, the report shall indicate clearly relevant values of the measured parameters for each setting of the adjustments, so that the values of inaccuracy, hysteresis, etc, can all be referenced to the same adjustment of the device.

4.1.1.2 Setting of span and lower range value adjustments

Generally, unless otherwise specified in the test programme, the test for accuracy related factors shall be carried out with the adjustments set at the settings A, B, C, D, listed below, and in accordance with Table 1 whenever the span and/or the lower range value adjustments are adjustable further than the adjustments for the manufacturing tolerances.

NOTE For tests of dynamic behaviour, functional characteristics, and drift, refer to the appropriate clauses of this standard.

Table 1 – Settings of span and lower range value adjustments

Kind of test		Adjustable span	Zero suppression and/or elevation
Complete Tests	Performance evaluation	A	B
	Type test		
Simplified Tests	Routine tests	C	D
	Sample test		

Setting A – Span adjustment set at the maximum and minimum values specified by the manufacturer, and at one intermediate value.

Setting B – Normally, tests will be done at only one setting of lower range value, without suppression or elevation, but further tests at minimum and maximum settings may be required if the effects are significant.

Setting C – Unless otherwise specified in the test programme, the span shall be as set by the manufacturer.

Setting D – Unless otherwise specified in the test programme, the lower range value shall be as set by the manufacturer.

4.1.2 Preconditioning cycles

Prior to recording observations, the DUT shall be preconditioned (see 7.12 of IEC 61298-1) and shall be exercised by three full range traverses in each direction.

4.1.3 Number of measurement cycles and test points

The performance of the DUT shall be verified over the full range for increasing and decreasing values.

Taking into account the economic aspects outlined in 5.2 of IEC 61298-1, the number of measurement cycles and of test points shall be the lowest possible. The number and location of the test points shall be consistent with the kind of test, the degree of accuracy desired, and the characteristic being evaluated.

The number of increasing and decreasing test points shall be the same for each pre-determined test point, with the exception of 0 % and 100 %, that are reached only when going downscale or upscale.

The number of measurement cycles and the number of the test points depend on the kind of test under consideration. Unless otherwise specified for a particular type of device, the values and locations that should be adopted are given in Table 2.

4.1.4 Additional tests where digital inputs and outputs are provided

Tests shall be made to ensure that the protocols comply with international standards (e.g., RS 232, IEEE 488) or the protocols fully specified by the DUT supplier. Tests shall be carried out to confirm that the DUT functions correctly to the specified protocol under reference conditions, and without error (or within any error rate specified by the supplier). The levels of logical "1" and "0" shall be determined. Appropriate tests shall also be made for display errors (missing digit sections, etc.), brightness, contrast, and angle of view before loss of brightness/contrast. The update rate shall be recorded, together with display (accuracy) errors.

4.1.5 Measurement procedure

The first measurement shall be performed to the first significant value of the scale after 0 % of input span (e.g., 10 % of input span – see Table 2).

Initially, an input signal equal to the lower range value is generated, and then the input signal is slowly increased to reach, without overshoot, the first test point; after an adequate stabilization period, the value of the corresponding input and output signal is noted.

Then the input signal is slowly increased to reach, without overshoot, the value of the next test point and, after a stabilization period, the corresponding value of the output signal is recorded.

The operation is repeated for all the predetermined values up to 100 % of the input span. After measurement at this point, the input signal is slowly brought down to the test value directly below 100 % of input span, and then to all the other values in turn down to 0 % of input span, thus closing the measurement cycle.

Table 2 – Number of measurement cycles and number and location of test points

Kind of test		Number of measurement cycles	Number of test points	Location of test points (% of input span)
Complete Tests	Performance evaluation	3 or 5	6	0-20-40-60-80-100
	Type tests		11	0-10-20-30-40-50-60-70-80-90-100
Simplified Tests	Routine tests	1	5	0-25-50-75-100
	Sample tests			

4.1.6 Processing of the measured values

The difference between the output signal values obtained at the various test points for each upscale and downscale traverse and the corresponding ideal values are recorded as the output errors.

The errors generally shall be expressed as percent of the ideal output span. On certain devices (e.g., recorders, or devices with adjustable gain), it may be more convenient to express the errors as percent of nominal input span (see 7.16 of IEC 61298-1).

For each measuring point, the readings obtained in successive cycles for upscale and downscale error, respectively, shall be averaged to give average upscale and downscale values, and these averaged to give the average value at that point.

All the error values thus obtained shall be shown in a table (see Table 3), and the average values shall be presented graphically (see Figure 1).

4.1.7 Determination of accuracy related factors

Because of the limited number of measurements (see 4.1.3), the accuracy related factors shall be determined by treating the errors in a mathematically simple way, and not on the basis of statistical methods. The different methods of treatment are described in the following clauses.

4.1.7.1 Inaccuracy

Inaccuracy is determined from Table 3 by selecting the greatest positive and negative deviations of any measured value from the ideal value for increasing and decreasing inputs for any test cycle separately, and reporting this in percent of ideal output span.

4.1.7.2 Maximum measured error

Maximum measured error is determined from table 3 by selecting the greatest positive or negative value from the average upscale errors and the average downscale errors.

4.1.7.3 Non-linearity

For devices that have a linear input/output relationship, the non-linearity is determined from the curve plotted using the overall average of corresponding upscale and downscale average errors (see Table 3 and Figure 1).

The maximum positive or negative deviation between the average curve and the selected straight line, expressed in percent of ideal output span, is the non-linearity, and is independent of dead band and hysteresis.

a) *Terminal based non-linearity*

Terminal based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the upper range value and at the lower range value.

NOTE Where calibrations in workshops and adjustments in the field are made, only terminal based non-linearity is of practical interest. Other expressions of non-linearity are sometimes used.

b) *Independent non-linearity*

Independent non-linearity is determined by drawing a straight line through the average curve in such a way as to minimize the maximum deviation. It is not necessary that the straight line be horizontal, or pass through the end points of the average calibration curve.

c) *Zero based non-linearity*

Zero based non-linearity is determined by drawing a straight line so that it coincides with the average calibration curve at the lower range value (zero), and minimizes the maximum deviation.