IEC 61514

Edition 2.0 2026-06

INTERNATIONAL STANDARD

REDLINE VERSION

Industrial-process control systems - Methods of evaluating the performance of valve positioners with pneumatic outputs

ICS 23.060.99; 25.040.40

ISBN 978-2-8327-1324-2

IEC 61514:2026-06 RLV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Industrial-process control systems - Methods of evaluating the performance of valve positioners with pneumatic outputs

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61514:2000. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61514 has been prepared by subcommittee 65B: Devices, of IEC technical committee 65: Industrial-process measurement and control. It is an International Standard.

This second edition cancels and replaces the first edition published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) in 6.6.8 and Table 5, the magnetic field has been changed from 100 A/m to of 30 A/m (Mean Root Square);

b) 6.10.4 and Figure 9 have been modified for better understandability;

c) in 7.4, the reference to IEC 61187 has been deleted and replaced with a new Table 4: Document information.

The text of this International Standard is based on the following documents:

Draft	Report on voting
65B/1309/FDIS	65B/1321/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,

– withdrawn, or

– revised.

1 Scope ~~and object~~

This International Standard specifies tests designed to determine the static and dynamic performance of single-acting or double-acting analogue positioners. The tests ~~may be applied~~ apply to positioners which receive standard analogue input signals (as specified in IEC 60381-1, IEC 60381-2 and IEC 60382) and have a pneumatic output.

~~NOTE For~~ Positioners with pulsed or digital input signals, ~~equivalent criteria may be applied. The methods described may not fully apply to~~ positioners with digital controllers ~~or~~ and positioners with pulsed outputs are outside the scope of this document.

Testing ~~may be~~ is conducted either on a positioner alone, independently of an actuator, or on a positioner mounted and connected to a specific actuator, as a combined unit. The text makes clear where different approaches are required.

The methods of evaluation given in this document 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 closest liaison should be maintained between the evaluating body and the manufacturer. Note should 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 programme and the results. His comments on the results should be included in any report produced by the testing organization.~~

The closest liaison between the evaluating body and the manufacturer is indispensable during the tests, including the possibility for the manufacturer to influence the test programme based on the manufacturer's specifications for the instrument and comment on both the test programme and the results.

This document is intended to provide definitions of positioner elements, actions, and characteristics, to specify uniform methods of measuring performance errors and effects of influence quantities on those characteristics, and to describe methods of reporting and evaluating the results of the measurement data obtained.

The test conditions described in this publication (for example range of ambient temperatures and power supply) relate to conditions which commonly arise in use. Consequently, the values specified ~~shall be~~ are used where no other values are specified by the manufacturer or user. If other values are used, they ~~should~~ will be stated. It is recognized that the manufacturer's specifications and instructions for installation and operation ~~should~~ apply during all steps.

The tests specified in this document are not necessarily sufficient for instruments specifically designed for unusually arduous conditions. Conversely, a reduced series of tests ~~may~~ can serve adequately for instruments designed to perform within a more limited range of conditions.

When a full evaluation, in accordance with this document, is not required or possible, ~~those~~ only the tests which are required ~~should be~~ are performed and the results reported in accordance with the relevant parts of this document. In such cases, the test report ~~should~~ will state that it does not cover the full number of tests specified herein.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*~~

IEC 60050-311, *International electrotechnical vocabulary - Electrical and electronic measurements - Part 311: General terms relating to electrical measurements*

IEC 60050-351, *International electrotechnical vocabulary - Part 351: Control technology*

IEC 60068-2-1~~:1990~~, *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 60068-2-6~~:1995~~, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

IEC 60068-2-31~~:1969~~, *Environmental testing - Part 2-31: Tests - Test Ec: ~~Drop and topple~~ Rough handling shocks, primarily for equipment-type specimens*

~~IEC 60068-2-56:1988, *Environmental testing – Part 2: Tests. Test Cb: Damp heat, steady state, primarily for equipment*~~

IEC 60068-2-78, *Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state*

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

IEC 60381-2, *Analogue signals for process control systems - Part 2: Direct voltage signals*

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

IEC 60529~~:1989~~, *DegreeS of protection provided by enclosures (IP Code)*

IEC 60654 (all parts), *Industrial-process measurement and control equipment - Operating conditions*

IEC 60721-3 (all parts), *Classification of environmental conditions - Part 3 Classification of groups of environmental parameters and their severities*

~~IEC 60902:1987, *Industrial-process measurement and control – Terms and definitions*~~

~~IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency electromagnetic field immunity test*~~

~~IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*~~

~~IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*~~

~~IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 8: Power frequency magnetic field immunity test*~~

IEC 61010-1~~:1990~~, *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 61187:1993, *Electrical and electronic measuring equipment – Documentation*~~

IEC 61298-4~~:1995~~, *Process measurement and control devices - General methods and procedures for evaluating performance - Part 4: Evaluation report content*

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

3 Terms and definitions

~~For the purpose of this standard, the definitions given in IEC 60902 and IEC 60050(161) shall be applied, in addition to the following definitions.~~

For the purposes of this document, the terms and definitions given in IEC 60050-311 and IEC 60050- 351 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
positioner
position controller connected to the moving part of a final control element or its actuator; automatically adjusts its output signal Y to the actuator in order to maintain a desired travel signal X that bears a predetermined relationship to the input signal W

Note 1 to entry: In this document, only positioners with pneumatic output signals Y are considered. The input signal W may be an air pressure (pneumatic positioner), or an electric current or voltage (electro-pneumatic positioner~~, or a pulse or digital signal~~).

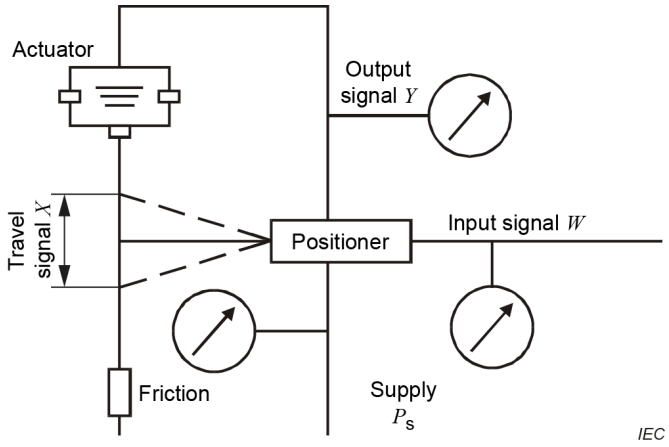
3.1.1
single-acting positioner
positioner having one output signal Y which acts on one side of the actuator

SEE: Figure 1 a).

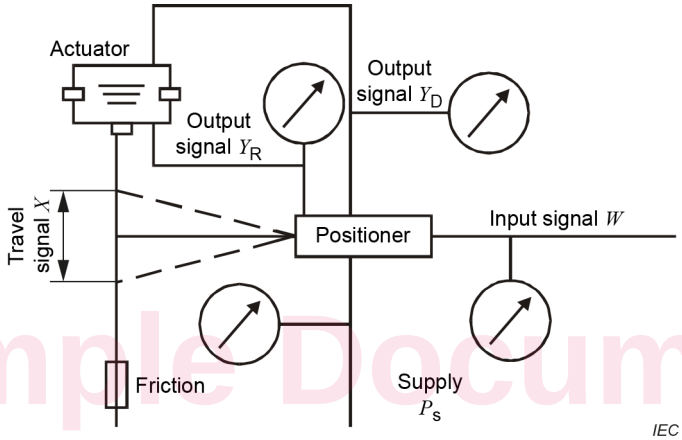
Note 1 to entry: The returning force for the actuator is usually provided by springs.

3.1.2
double-acting positioner
positioner providing two output signals Y_D and Y_R connected to opposite sides of the actuator diaphragm or piston

SEE: Figure 1 b).



a) Single-acting positioner/actuator



b) Double-acting positioner/actuator

Figure 1 – Single- and double-acting positioner/actuator

3.2
input signal W
reference input signal which represents the desired position of the associated control element

3.3
travel signal X
signal which results from the linear or angular travel caused by movement of the final control element or its actuator

3.4
output signal Y
air pressure delivered to the actuator of the final control element

3.5
supply pressure ~~P_s~~
air pressure at the supply connector of the positioner

3.6
action
~~action is direct when the output signal Y increases as the value of the input signal W increases. The action is reverse when the output signal Y decreases as the value of the input signal W increases~~

direction of the output signal Y in relation to the direction of the input signal W

3.6.1
direct action
output signal Y increases as the value of the input signal W increases

3.6.2
reverse action
output signal Y decreases as the value of the input signal W increases

3.7
split ranging
special adjustment in which the full travel of the actuator is achieved from only part of the whole input range (for example 0 % to 50 % or 50 % to 100 %)

3.8
gain characteristic
relationship between input signal W and output signal Y with travel signal X kept constant (i.e. locked stem)

SEE: Figure 2.

Note 1 to entry: Incremental gain $\Delta Y/\Delta W$ varies with pressure and the related pressure shall be stated.

3.9
proportional ~~(average)~~ gain factor K_p
gain over the full range of the actuator

Note 1 to entry: The proportional gain factor for a single-acting positioner ~~may~~ can be derived from the gain characteristic (Figure 2 a)):

$$K_p = \frac{\Delta Y_{max}}{\Delta W_{max}}$$

where ΔW_{max} is the change of input signal W as a percentage of span required to change the output signal over the whole range (ΔY_{max} for 100 %). In this case ΔW_{max} (%) corresponds to the proportional band X_p (%). The output signal range ΔY_{max} is taken to be the nominal range stated by the manufacturer.

For a double-acting positioner, a proportional gain factor for each output may be derived separately (see Figure 2 b):

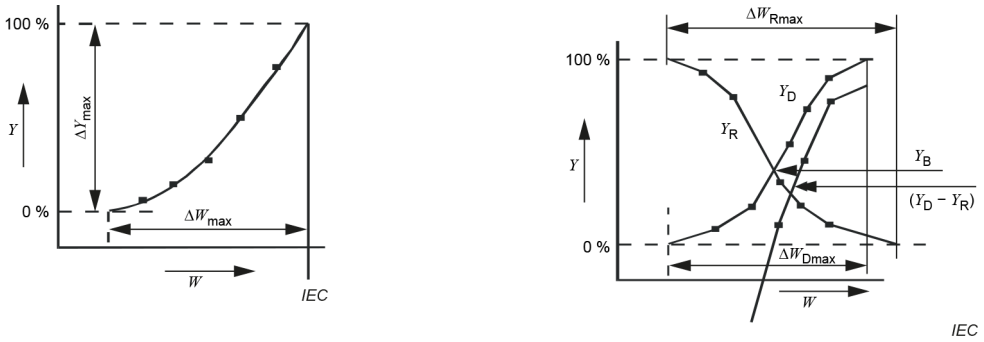
$$K_{pD} = \frac{\Delta Y_{max}}{\Delta W_{Dmax}} \qquad K_{pR} = \frac{\Delta Y_{max}}{\Delta W_{Rmax}}$$

The proportional gain factor K_p for a double-acting positioner ~~may~~ can then be calculated as the summation of the two individual gain factors, i.e.:

$$K_p = K_{pD} + K_{pR}$$

or derived from the differential pressure characteristic ($Y_D - Y_R$); see Figure 2 b.

The balance pressure Y_B is the cross-over point of the direct Y_D and reverse Y_R characteristics. Generally, this value depends on the supply pressure applied to the positioner.



a) Single-acting positioner

b) Double-acting positioner

Figure 2 – Gain characteristic

3.10
proportional band X_p
is defined as

$$X_p(\%) = \frac{100\ \%}{K_p}$$

local gain factor K_l
slope of the gain characteristic at a specific input value

3.11
travel characteristic

closed-loop relationship of a positioner/actuator between the input signal W and the travel signal X

Note 1 to entry: The intended relationship between input signal W and travel signal X (for example linear or equal percentage) determines the ideal characteristic.

~~**3.13**~~
~~**travel factor *U***~~
~~ratio between the travel span and the corresponding input span. This may be adjustable.~~

3.12
~~**maximum**~~ **measured error**
~~largest~~ positive or negative value of error of the average up-scale or down-scale value at each point of measurement

4 General conditions for tests

4.1 Environmental test conditions

4.1.1 General

The tests shall be performed under the ambient test conditions recommended below:

Table 1 – Environmental conditions

Atmospheric test conditions	Temperature °C	Relative humidity %	Atmospheric pressure kPa
Standard reference atmosphere	20	65	101,3
Recommended limits	15 to 25	45 to 75	86 to 106
Referee measurements a:	20 ± 2	65 ± 5	86 to 106
b:	23 ± 2	50 ± 5	86 to 106

The test values shall be corrected back to the standard reference atmosphere conditions listed above. The standard reference atmosphere is equivalent to the normal reference operating conditions commonly identified by the manufacturer.

It is recognized that there ~~may not~~ cannot be a factor to correct for humidity. When measurements within the recommended range of ambient conditions are unsatisfactory, and the correction factors to adjust parameters to the standard atmosphere are unknown, repeat measurements (referee measurements) may be conducted under the conditions listed in Table 1, a or b, or other reference operating conditions identified by the manufacturer.

NOTE ~~—~~ Special equipment ~~may~~ can be required to maintain the basic test conditions within the limits specified.

4.1.2 ~~Recommended~~ Limits of ambient conditions for test measurements

Electromagnetic field: value ~~to~~ shall be stated, if relevant.

Maximum rate of change of ambient temperature permissible during any test: 1 °C in 10 min, but not more than 3 °C/h.

4.2 Supply conditions

4.2.1 Reference values

Electrical supply: the values specified by the manufacturer.

Pneumatic supply: the values specified by the manufacturer, or a supply pressure of 4,0 bar (400 kPa).

4.2.2 Tolerances

The tolerances given below apply, unless closer tolerances are agreed between user and manufacturer.

a) Electrical supply
   1) Rated voltage: ±1 %.
   2) Rated frequency: ±1 %.
   3) Harmonic distortion (AC supply): less than 5 %.

4) Ripple (DC supply): less than 0,1 %.

b) Pneumatic supply

1) Rated pressure: ±3 %;

2) Supply air temperature: ambient temperature ±2 °C.

3) Supply air humidity: dew-point at least 10 °C below device body temperature.

4) Oil and dust content

i) oil: less than 10^{-6} by weight;

ii) dust: absence of particles greater than 3 µm in diameter.

5 General testing procedures

5.1 Test equipment

When the accuracy rating of the reference measuring means is one-tenth or less than that of the device under test, the accuracy rating of the reference measuring means may be ignored in calculations, but shall be reported. When the accuracy rating of the reference measuring means is one-third or less, but greater than one-tenth of that of the device under test, the accuracy rating of the reference measuring means shall be stated in the report.

5.2 Test methods

Specific test methods and test configurations are described separately in Clause 6.

5.3 Testing precautions

Unless affecting the influence condition being tested, the following conditions shall apply.

An adequate time, as specified by the manufacturer, shall be allowed after switching on the power supply in order to allow stabilization of the positioner and/or associated test equipment. In the absence of a manufacturer specification, a period of at least 15 min shall be allowed (at least 30 min for electrical supplies).

Prior to recording observations, the device under test shall be exercised by three or more full range traverses in each direction.

The measurement points used to determine the relevant performance characteristic should be distributed over the range. They should include points at or near (within 10 %) the lower- and upper-range values. There should be at least six measurement points, and preferably more. The number and location of these measurement points should be consistent with the degree of precision required and the characteristic being evaluated. Each measurement point should be reached avoiding any overshoot of the input signal.

At each point being observed, the recording shall be made after the device becomes stabilized at its apparent steady-state value.

Tapping or vibrating the device under test is not allowed unless the performance characteristic under study requires such action.

All testing should be conducted with positioner covers in place.

Any mechanical stops should be adjusted so that they do not interfere with the measurements.