

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

The European Standard EN 61514:2002 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 61514:2002. It was derived by CENELEC from IEC 61514:2000.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by common modification tags **[C]** **[C]**.

Those parts of the original IEC text that have been modified by CENELEC have been identified in national annex NA.

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

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**Industrial-process control systems -
Methods of evaluating the performance of valve positioners
with pneumatic outputs
(IEC 61514:2000, modified)**

Systèmes de commande
des processus industriels -
Méthodes d'évaluation des performances
des positionneurs de vannes
à sorties pneumatiques
(CEI 61514:2000, modifiée)

Systeme der industriellen Prozesstechnik -
Methoden der Beurteilung
des Betriebsverhaltens
von Ventilstellungsreglern
mit pneumatischen Ausgängen
(IEC 61514:2000, modifiziert)

This European Standard was approved by CENELEC on 2001-12-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 61514:2000, prepared by SC 65B, Devices, of IEC TC 65, Industrial-process measurement and control, together with the common modifications prepared by SR 65B, was submitted to the formal vote and was approved by CENELEC as EN 61514 on 2001-12-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
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- latest date by which the national standards conflicting
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Endorsement notice

The text of the International Standard IEC 61514:2000 was approved by CENELEC as a European Standard with agreed common modifications.

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INDUSTRIAL-PROCESS CONTROL SYSTEMS – Methods of evaluating the performance of valve positioners with pneumatic outputs

1 Scope and object

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

Positioners with pulsed or digital input signals, positioners with digital controllers and positioners with pulsed outputs are outside the scope of this standard. Ⓒ

Ⓒ Ⓒ

Testing may be 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 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 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.

This standard 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 used where no other values are specified by the manufacturer or user. If other values are used, they should 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 standard are not necessarily sufficient for instruments specifically designed for unusually arduous conditions. Conversely, a reduced series of tests may serve adequately for instruments designed to perform within a more limited range of conditions.

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

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of IEC 61514. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on IEC 61514 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60068-2-1:1990, *Environmental testing – Part 2: Tests. Test A: Cold*

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

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests. Test Fc: Vibration (sinusoidal)*

IEC 60068-2-31:1969, *Environmental testing – Part 2: Tests. Test Ec: Drop and topple, 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 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 60529:1989, *Degree of protection provided by enclosures (IP Code)*

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*

3 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.

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 In this standard, 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 (see figure 1a) having one output signal Y which acts on one side of the actuator. The returning force for the actuator is usually provided by springs

3.1.2 double-acting positioner

positioner (see figure 1b) providing two output signals Y_D and Y_R connected to opposite sides of the actuator diaphragm or piston

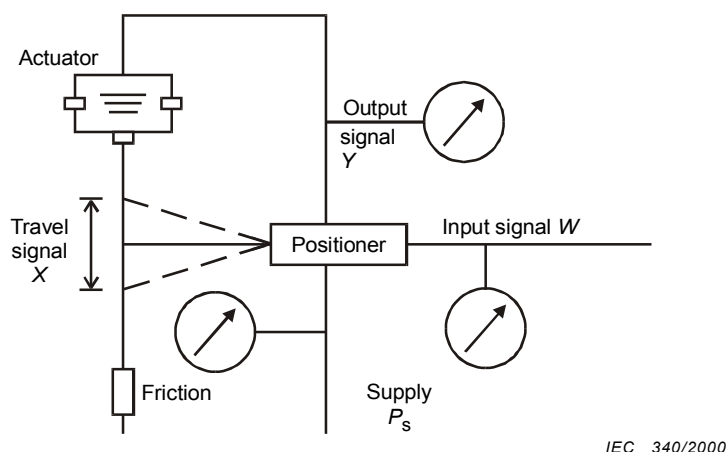


Figure 1a – Single-acting positioner/actuator

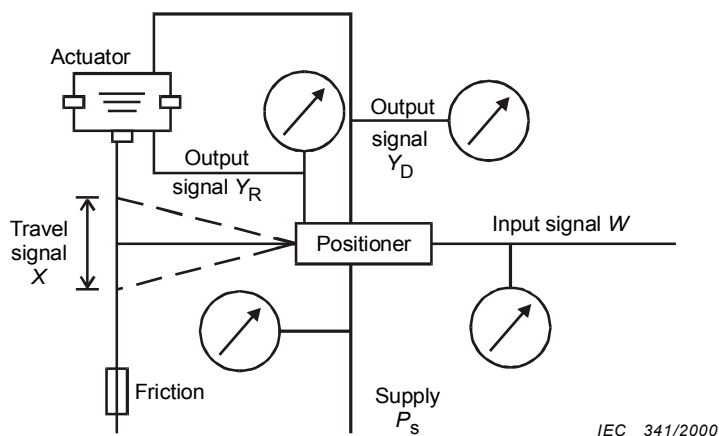


Figure 1b – Double-acting positioner/actuator

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

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

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. The proportional gain factor for a single-acting positioner may be derived from the gain characteristic (figure 2a):

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

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

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

$$K_{pD} = \frac{\Delta Y_{\max}}{\Delta W_{D\max}}$$

$$K_{pR} = \frac{\Delta Y_{\max}}{\Delta W_{R\max}}$$

The proportional gain factor K_p for a double-acting positioner may 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 2b.

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.

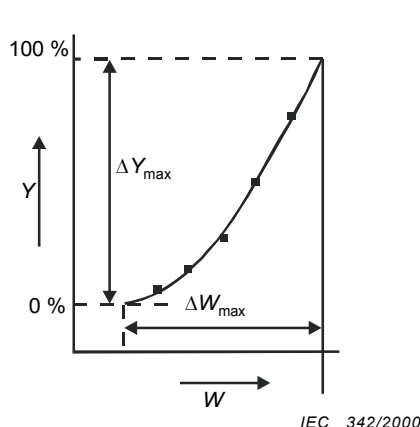


Figure 2a – Single-acting positioner

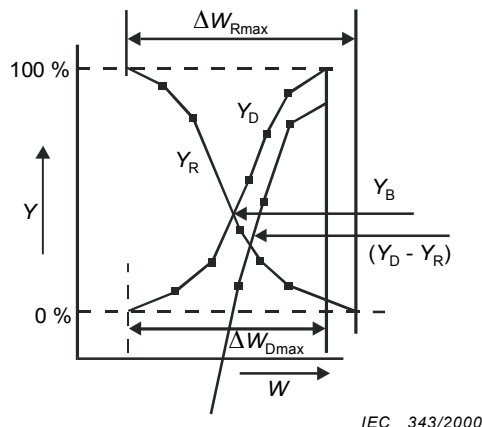


Figure 2b – Double-acting positioner

Figure 2 – Gain characteristic

3.10

proportional band X_p

the proportional band X_p is defined as

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

3.11

local gain factor K_l

slope of the gain characteristic at a specific input value

3.12

travel characteristic

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

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.

3.14

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

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 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 be required to maintain the basic test conditions within the limits specified.

4.1.1 Recommended limits of ambient conditions for test measurements

Electromagnetic field: value to 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

- Rated voltage: ± 1 %.
- Rated frequency: ± 1 %.
- Harmonic distortion (a.c. supply): less than 5 %.
- Ripple (d.c. supply): less than 0,1 %.

b) Pneumatic supply

- Rated pressure: ± 3 %;
- Supply air temperature: ambient temperature ± 2 °C.
- Supply air humidity: dew-point at least 10 °C below device body temperature.
- Oil and dust content
 - oil: less than 10^{-6} by weight;
 - 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.

All tests shall be conducted with the device in an agreed mounting position(s), which shall be stated in the report.

Characteristics and data which are dependent on the supply pressure value (for example air consumption, flow capacity, etc.) should be measured at minimum and maximum values of the specified supply pressure range.

Positioners fitted with a cam shall be tested with input/travel characteristics which are normally linear.

5.4 Basic test arrangement

The basic test arrangements are shown in figures 3a and 3b.

5.4.1 Positioner tested independently of an actuator

Tests carried out on a positioner, tested independently of an actuator, are conducted with the output *Y* of the positioner connected only to a dummy load (sometimes referred to as "open-loop" operation).

Unless otherwise agreed, a 1 000 cm³ volume shall be connected to the output. In this way, the performance of the positioner is not affected by the performance of the actuator.

This is the only test method which provides positioner data independent of an actuator, and may be useful in comparing the performance of one positioner with another, or in checking a manufacturer's specification for a positioner.

The travel adjustment can be made manually or by using an actuator (manually controlled).

The input signal *W* can be manually adjusted to obtain the required re-balance of output signal *Y*, or a loop between output signal *Y* and input signal *W* can be arranged if desired, i.e. automatic re-balance.

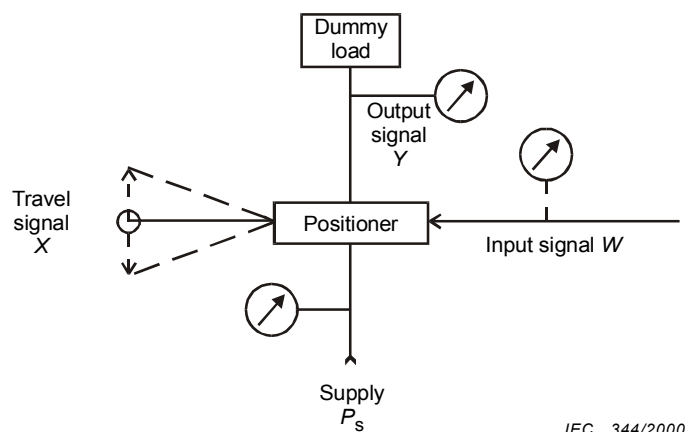


Figure 3a

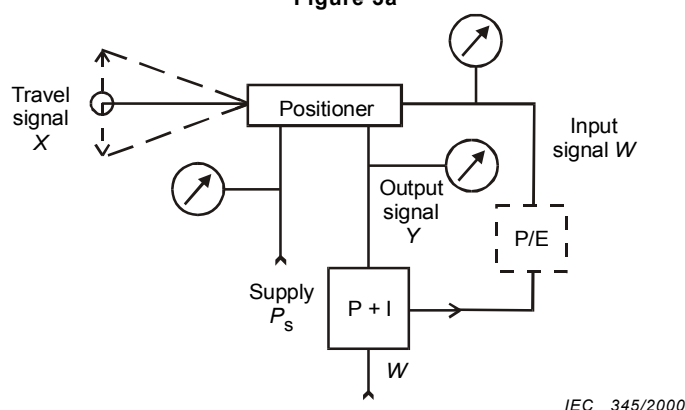


Figure 3b

Figure 3 – Basic test arrangement

NOTE 1 With positioners possessing an additional integral mode (i.e. PI control action) it is necessary to use an automatic re-balance loop to achieve stable measurements. In this case, the output Y of the positioner is connected to the input (+) of the pneumatic rebalance device (for example summing relay or PI controller), whose output is fed back to the input W of the positioner. In cases where the input W is an electrical signal, a pressure/electrical converter must be included in the circuit, after the re-balance device. The arrangement for this additional test is shown in figure 3b.

NOTE 2 The input signal W can be a pressure or an electrical signal. The output signal Y is a pressure. The normal test procedure will be to set the travel input signal X to some desired position and then to adjust the input signal W sufficiently to balance a change in output signal Y .

5.4.2 Positioner tested in conjunction with an actuator

Tests carried out in conjunction with an actuator are conducted on a positioner when it is mounted on and connected to an actuator, as a complete positioner/actuator assembly.

The positioner may be fitted to any commercially available actuator with which it is compatible. The selected actuator is the choice of the user or the manufacturer. Generally, the results of tests may be affected by performance of the actuator used for the test. Therefore, supporting information about the actuator used (such as friction, inertia, type of packing material, etc.) should be included in the presentation of the test report (see clause 8).

NOTE 1 The input signal W can be a pressure or an electrical signal. Some means of accurately measuring the travel X is necessary. The normal test procedure will be to set the input signal W to some desired value and then to read the corresponding value of the travel signal X .

NOTE 2 Since the output pressure signals Y (or Y_D and Y_R for a double-acting positioner) are connected to the actuator (sometimes referred to as "closed-loop" operation) and since their actual values are only an internal signal, they need be measured only if specifically required.