BS EN 61514-2:2013

BSI Standards Publication

Industrial process control systems

Part 2: Methods of evaluating the performance of intelligent valve positioners with pneumatic outputs mounted on an actuator valve assembly

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National foreword

This British Standard is the UK implementation of EN 61514-2:2013. It is identical to IEC 61514-2:2013. It supersedes BS EN 61514-2:2004, which will be withdrawn in 1 August 2016.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations.

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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English version

Industrial process control systems - Part 2: Methods of evaluating the performance of intelligent valve positioners with pneumatic outputs mounted on an actuator valve assembly
(IEC 61514-2:2013)

Systèmes de commande des processus industriels -
Partie 2: Méthodes d'évaluation des performances des positionneurs de vanne intelligents à sorties pneumatiques montés sur un ensemble actionneur/vanne
(CEI 61514-2:2013)

Systeme der industriellen Prozessleittechnik – Teil 2: Verfahren zur Bewertung des Betriebsverhaltens von intelligenten Ventilstellungsreglern mit pneumatischem Ausgang, die an Ventil-Stellantrieben montiert sind
(IEC 61514-2:2013)

This European Standard was approved by CENELEC on 2013-08-01. 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 CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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CENELEC

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

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Foreword

The text of document 65B/868/FDIS, future edition 2 of IEC 61514-2, 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 approved by CENELEC as EN 61514-2:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-05-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-08-01

This document supersedes EN 61514-2:2004.

EN 61514-2:2013 includes the following significant technical changes with respect to EN 61514-2:2004:

– The standard has been optimized for usability.
– The test procedures have been reviewed regarding applicability for use in test facilities. Impractical test procedures were removed or modified.

EN 61514-2:2013 is to be used in conjunction with EN 61514:2002.

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

Endorsement notice

The text of the International Standard IEC 61514-2:2013 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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	Series	International Electrotechnical Vocabulary (IEV)	-	-
IEC 60068-2-1	1990	Environmental testing - Part 2: Tests - Tests A: Cold	EN 60068-2-1[1)]	1993
IEC 60068-2-2	1974	Environmental testing - Part 2: Tests - Tests B: Dry heat	EN 60068-2-2[2) 3)]	1993
IEC 60068-2-6	1995	Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6[4)]	1995
IEC 60068-2-31	1969	Environmental testing. Part 2: Tests. Test Ec: Drop and topple, primarily for equipment-type specimens	EN 60068-2-31[5) 6)]	1993
IEC 60068-2-78	2001	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78[7)]	2001
EN 60079	Series	Electrical apparatus for explosive gas atmospheres	-	-
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 1993
IEC 60534-1	-	Industrial-process control valves - Part 1: Control valve terminology and general considerations	EN 60534-1	-
IEC 60654	Series	Industrial-process measurement and control equipment - Operating conditions	EN 60654	Series
IEC 60721-3	-	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities	EN 60721-3	-
IEC 61000-4-11	-	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	-

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[1)] EN 60068-2-1 is superseded by EN 60068-2-1:2007, which is based on IEC 60068-2-1:2007.

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

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

[4)] EN 60068-2-6 is superseded by EN 60068-2-6:2008, which is based on IEC 60068-2-6:2007.

[5)] EN 60068-2-31 includes A1 to IEC 60068-2-31.

[6)] EN 60068-2-31 is superseded by EN 60068-2-31:2008, which is based on IEC 60068-2-31:2008.

[7)] EN 60068-2-78 is superseded by EN 60068-2-78:2013, which is based on IEC 60068-2-78:2012.

Publication	Year	Title	EN/HD	Year
IEC 61010-1 + corr. May + corr. April	2001 2001 2003	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements	EN 61010-1 + corr. June [9]	2001 2002
IEC 61032 + corr. January	1997 2003	Protection of persons and equipment by enclosures - Probes for verification	EN 61032	1998
EN 61069	Series	Industrial-process measurement and control - Evaluation of system properties for the purpose of system assessment	-	-
IEC 61158	Series	Industrial communication networks - Fieldbus specifications	EN 61158	Series
IEC 61298	Series	Process measurement and control devices - General methods and procedures for evaluating performance	EN 61298	Series
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
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
IEC 61326-1 + corr. February + corr. February	2005 2010 2008	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	EN 61326-1 [11]	2006
IEC/PAS 61499	Series	Function blocks for industrial-process measurement and control systems	-	-
IEC 61514 (mod)	2000	Industrial-process control systems - Methods of evaluating the performance of valve positioners with pneumatic outputs	EN 61514	2002
IEC/TS 62098	-	Evaluation methods for microprocessor-based instruments	-	-
CISPR 11	-	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	-

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

[11] EN 61326-1 is superseded by EN 61326-1:2013, which is based on IEC 61326-1:2012.

CONTENTS

INTRODUCTION

New instruments for process control and measurement including valve positioners are mainly equipped with microprocessors, thereby utilising digital data processing and communication methods and/or artificial intelligence, making them more complex and giving them a considerable added value.

Modern intelligent valve positioners are no longer only controlling the valve position, but they are in many cases also equipped with various facilities for self-testing, actuator/valve condition monitoring and alarming. The variety of added functionalities is large. They can no longer be compared with the single function "cam-type" positioners. Therefore, accuracy related performance testing, although still very important, is no longer sufficient to demonstrate their flexibility, capabilities and other features with respect to engineering, installation, maintainability, reliability and operability.

In this standard the evaluation considers performance testing and a design review of both hardware and software. The layout of this document follows to some extent the framework of IEC/TS 62098. A number of performance tests described in IEC 61514 are still valid for intelligent valve positioners. Further reading of IEC 61069 is recommended.

INDUSTRIAL PROCESS CONTROL SYSTEMS –

Part 2: Methods of evaluating the performance of intelligent valve positioners with pneumatic outputs mounted on an actuator valve assembly

1 Scope

This part of IEC 61514 specifies design reviews and tests intended to measure and determine the static and dynamic performance, the degree of intelligence and the communication capabilities of single-acting or double-acting intelligent valve positioners. The tests may be applied to positioners which receive standard analogue electrical input signals (as specified in IEC 60381) and/or digital signals via a data communication link and have a pneumatic output. An intelligent valve positioner as defined in Clause 3 is an instrument that uses for performing its functions digital techniques for data processing, decision-making and bi-directional communication. It may be equipped with additional sensors and additional functionality supporting the main function.

The performance testing of an intelligent valve positioner needs to be conducted with the positioner mounted on and connected to the actuator/valve assembly the positioner is to be used on. The specific characteristic parameters of these combinations such as size, stroke, friction (hysteresis), type of packing, spring package and supply pressure for the pneumatic part, should be carefully chosen and reported, since the performance of a positioner is greatly dependent on the used actuator.

The methods of evaluation given in this standard are intended for testing laboratories to verify equipment performance specifications. The manufacturers of intelligent positioners are urged to apply this standard at an early stage of development.

This standard is intended to provide guidance for designing evaluations of intelligent valve positioners by providing:

– a checklist for reviewing their hardware and software design in a structured way;
– test methods for measuring and qualifying their performance under various environmental and operational conditions;
– methods for reporting the data obtained.

When a full evaluation, in accordance with this standard, is not required or possible, the tests which are required should be performed and the results should be 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. Furthermore, the items omitted should be mentioned, to give the reader of the report a clear overview.

The standard is also applicable for non-intelligent microprocessor-based valve positioners without means for bi-directional communication. In that case an evaluation should be reduced to a limited programme of performance testing and a short review of the construction.

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at http://www.electropedia.org)

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

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests. Tests 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 60068-2-78:2001, *Environmental testing – Part 2-78: Tests. Test Cab: Damp heat, steady state*

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

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

IEC 60534-1, *Industrial-process control valves – Part 1: Control valve terminology and general considerations*

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

IEC 60721-3, *Classification of environmental conditions – Part 3 Classification of groups of environmental parameters and their severities*

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

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 61069 (all parts), *Industrial-process measurement and control – Evaluation of system properties for the purpose of system assessment*

IEC 61158 (all parts), *Digital data communications for measurement and control – Fieldbus for use in industrial control systems*

IEC 61298 (all parts), *Process measurement and control devices – General methods and procedures for evaluating performance*

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*

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

IEC/PAS 61499 (all parts), *Function blocks for industrial-process measurement and control systems*

IEC 61514:2000, *Industrial-process control systems – Methods of evaluating the performance of valve positioners with pneumatic outputs*

IEC/TS 62098, *Evaluation methods for microprocessor-based instruments*

CISPR 11, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61514:2000 and IEC 60050-351, as well as the following apply.

3.1
intelligent valve positioner
position controller based on microprocessor technology, and utilising digital techniques for data processing, decision-making and bi-directional communication

Note 1 to entry: It may be equipped with additional sensors and additional functionality supporting the main function.

Note 2 to entry: In this standard, only positioners with pneumatic output signals are considered, as defined in 3.1 of IEC 61514:2000. The input signal may be an electric current or voltage, or a digital signal via a fieldbus.

Note 3 to entry: For non-intelligent microprocessor-based position controllers without bi-directional communication an evaluation is reduced to a limited amount of performance testing and an abridged design review of the construction.

3.2
configuring
process of implementing the functionality required for a certain application

3.3
configurability
extent to which an intelligent positioner can be provided with functions to control various applications

3.4
calibration
process of adjusting the range of travel to the required value for acquiring a defined input-to-travel characteristic

Note 1 to entry: The adjusted travel can either be from stop to stop or to a value in between as defined by the valve manufacturer.

Note 2 to entry: Instruments may exist that are provided with an automatic procedure for travel range adjustment, which may then be addressed with the term auto-calibration.

3.5
tuning
process of adjusting the various control parameters for a certain application

Note 1 to entry: The stem tuning procedure can range from "trial and error" to an automatic proprietary procedure provided by the manufacturer and often addressed as auto-tuning.

3.6
set-up
process of configuring, calibrating and tuning a positioner for optimal controlling of a specific actuator/valve assembly

3.7
travel cut-off
point close to the extreme end (low or high) of the characteristic curve at which the positioner forces the valve to the corresponding mechanical stop (fully closed or fully open)

3.8
stroke time
time required to travel between two different positions under a defined set of conditions

3.9
dead band
finite range of values within which reversal of the input variable does not produce any noticeable change in the output variable

3.10
operating mode
selected method of operation of the positioner

3.11
setpoint
input variable, which sets the desired value of the controlled variable (travel)

Note 1 to entry: The input variable may originate from an analogue source (mA or voltage) or from a digital source (fieldbus) or local keyboard).

3.12
balance pressure
average of the pressures on the opposite chambers of a double acting actuator in steady state condition

Note 1 to entry: The balance pressure shall be expressed as a percentage of the positioner supply pressure to evaluate the stiffness of the double acting system.

4 Design review

4.1 General

The observations of Clause 4 shall be based on open literature (manuals, instruction leaflets, etc.) provided to a user on delivery of the instruments and whatever the manufacturer is willing to disclose. They shall not contain confidential information.

The design review is meant to identify and make explicit the functionality and capabilities of the intelligent valve positioner under consideration in a structured way. As intelligent positioners appear in a great variety of designs a review has to show in a structured way the details of

– their physical structure;
– their functional structure.

Subclause 4.2 guides the evaluator in the process of describing the physical structure of intelligent positioners through identifying the hardware modules and the I/Os to the operational and environmental domains.

Thereafter the functional structure is described using the checklist of 4.3. The checklist gives a structured framework of the relevant issues, which have to be addressed by the evaluator through adequate qualitative and quantitative experiments.

4.2 Positioner identification

4.2.1 Overview

The structured identification process, based on the following considerations, leads to a blockscheme and a concise description of the positioner under test, which shall be included in the evaluation report. It may be enhanced with photographs or drawings of important details.

The instrument, schematically shown in Figure 1, can have the following main physical modules and provisions for connection to the external world:

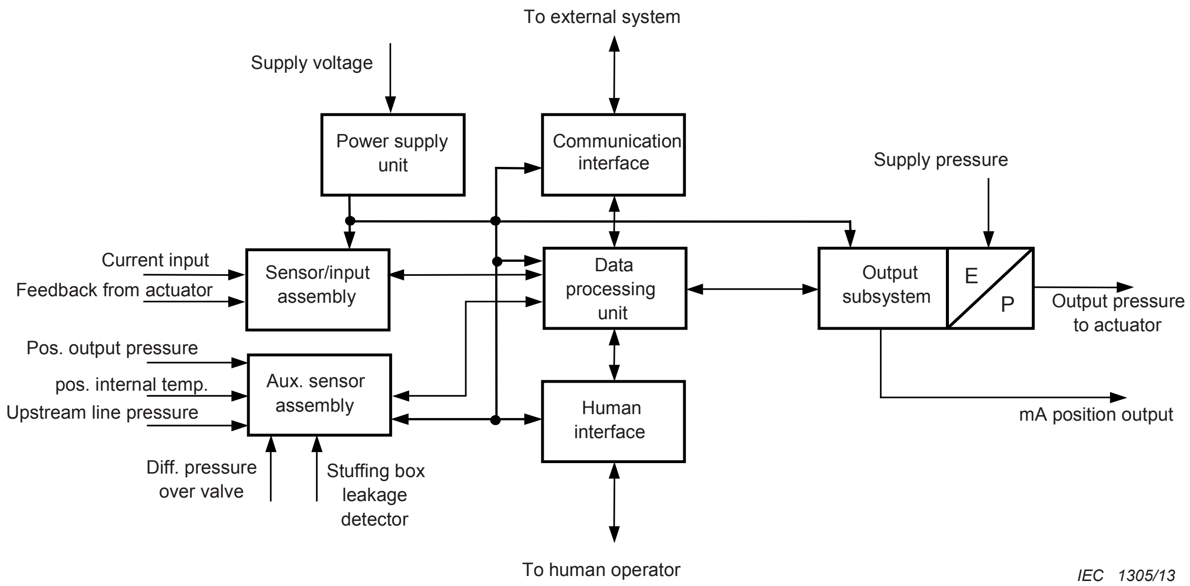

Figure 1 – Positioner model in extensive configuration

4.2.2 Power supply unit

Instruments that require a separate connection to an a.c. or d.c. supply voltage may exist. However, the majority of instruments are "loop powered" which means that they receive power either through the current input for instruments that need an analogue (mA) setpoint, or through the fieldbus when the setpoint is a digital signal.

4.2.3 Sensor/input assembly

The main sensor/input assembly is that part of the positioner to which the analogue setpoint is connected and which also receives the feedback signal from the actuator/valve assembly (stem movement). It supports the primary function of the positioner. Parts of the assembly may be distributed at physically different locations in the positioner. In instruments that receive a digital setpoint, the current input as shown in Figure 4 does not exist. The feedback signal is generated by a mechanical interface (linkage) between the positioner and the valve stem.

4.2.4 Auxiliary sensor assembly

The auxiliary sensor assembly is for the electronics part integrated with the main sensor input assembly. Many positioners are equipped with a pressure sensor in the pneumatic output circuit and a temperature sensor inside the electronics housing. Their signals may be used in the stem position control algorithm. For safeguarding and condition monitoring of the valve a positioner may be equipped with additional sensors. It may also be equipped with circuits for digital inputs from switches.

4.2.5 Human interface

A positioner can be classified as intelligent only when data produced by the positioner can be communicated to the external world. The human interface is an important tool for communication. It consists of integral means at the instrument for reading out data (local display) and provisions for entering and requesting data (local pushbuttons). It may appear that some instruments are not equipped with a human interface. In these cases access is provided via the data communication interface and an external device (handheld terminal or PC).

4.2.6 Communication interface

Positioner intelligence is further supported by the communication interface, which connects the positioner to external systems. Through the interface and a fieldbus, data transfer (setpoint, configuration and process data) takes place between the positioner and the external system. There are also hybrid instruments, which require an analogue input for control data where the data communication interface is integrated in the input circuit and has no separate point of connection for the fieldbus. The digital information is superimposed on the analogue input current. There may be instruments which do not have a communication interface. Then configuration and read-out of data take place via the human interface.

4.2.7 Data processing unit

The data processing unit provides the instrument with a number of functions that may vary considerably from make to make. The functions that can be implemented include:

– control function;
– configuration;
– calibration;
– tuning;
– valve condition monitoring (valve diagnostics);
– external process control function;
– self-testing;
– trending and data storage;
– part of the functionality may be located in external devices that are temporarily or continuously connected to the data communication interface (e.g. configuration, trending).

4.2.8 Output subsystem

In the single acting version the output subsystem converts the digital information via an electro-pneumatic converter (E/P) into the pneumatic signal for controlling the actuator.

In the double acting version the output subsystem is equipped with two oppositely operating E/P converters. In balanced (steady) position the converters provide pressures that, apart from the friction force to the valve stem, are equal. The relation between the balance pressure and the supply pressure determines the stiffness of a double acting system.

With respect to the pneumatic unit, the following two designs are, among others, commonly used:

– analogue techniques of conventional E/P converters as shown in Figure 2;
– electronically controlled two-state pilot valves.

Moreover, the output subsystem can also be provided with isolated analogue signal outputs proportional to one (or more) of the measured or calculated data and/or one or more configurable output relays for alarm purposes. Such outputs usually require a separate power supply.

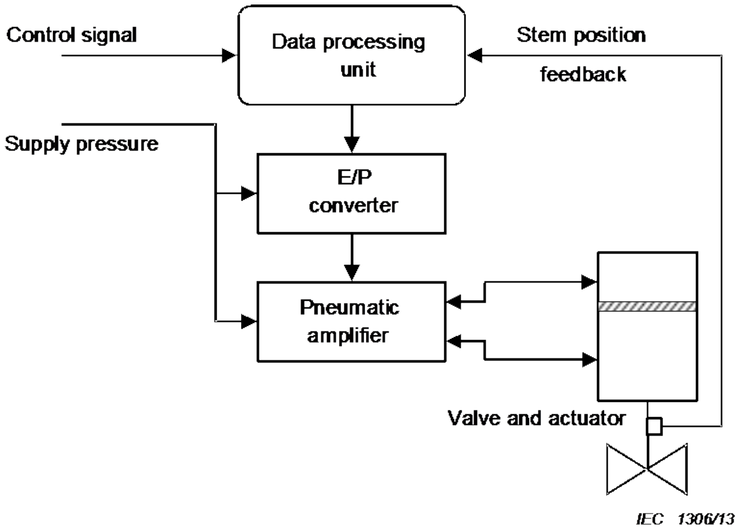

Figure 2 – Basic design for positioners with analogue outputs

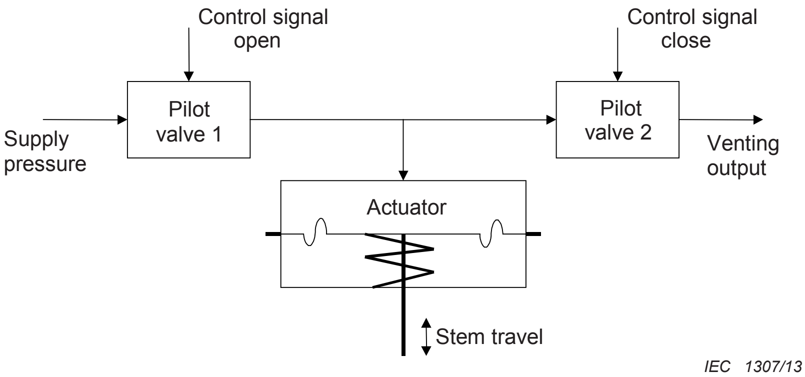

Figure 3 – Basic design for positioners with pulsed output

4.2.9 External functionality

Through the data communication interface and the fieldbus the instrument communicates with PCs, handheld devices and DCS systems. In many cases a part of the functionality of the positioner may reside in these devices. This may include the following functions:

– (Remote) configuration tool.
– Data storage (configuration, position trend, valve condition).
– Parts of the calibration and stem tuning procedure.
– Automated valve condition monitoring and alarming.

In an evaluation the external functionality (if present) shall be considered as well.

4.3 Aspects of functionality and capabilities to be reviewed

4.3.1 Checklist

The following Tables 1 through 5 shall serve as a checklist for the determination of the functions and capabilities implemented in the positioner under consideration. An example of the reporting format can be found in 4.4.

Table 1 – Functionality *(1 of 2)*

Function/capability	Aspects to be considered during evaluation
Suitable for rotary valve	If so, also indicate the stroke range and describe the accessories required for mechanical linkage.
Suitable for linear stroke valve	If so, also indicate the stroke range and describe the accessories required for mechanical linkage.
Direct/reverse action	Check whether choice of direct/reverse action is possible and describe how the mechanism operates.
Double acting version	Check one of the following: – always included – can be retrofitted – available with different order number – not available
Stem position control algorithm parameters	For each control parameter give: – name – adjustment range if user-adjustable – default values if applicable – check whether invalid values are recognised and rejected – check whether negative values are accepted, if so observe behaviour on instability after step change – check if outputs of internal sensors are used in the stem position control algorithm and check whether and how backup is provided in case of sensor failure – some designs have a double set of control parameters for upscale or downscale movement, verify – what value defines indefinite (‘99999’ or ‘0’)?
Other parameters affecting control	For a number of parameters (supply pressure, valve and actuator data, etc.) values may be requested to be entered during configuration. They might be used in the stem position control algorithm. Check whether they are indeed used in the stem position control algorithm or are informative only.
Operating modes	List the available operating modes, their hierarchy, span of control, switching order (also check availability of bumpless transfer), degree of authorised access to positioner database (configuration, control parameters, secondary parameters). Operating modes could be: – out of service or standby – automatic control – manual control (local or remote)
Split range application	Is split range operation possible? If so, state the adjustable value range.
Stroke time	Check whether the stroke time is user-adjustable. State the adjustable value range.
Travel cut-off	Cut-off is usually possible at the lower end of the characteristic (also known as tight shut-off), but also cut-off at the upper end can be present. Indicate which option is available and whether cut-off values are user-configurable. Check whether a dead band is implemented and operational between activation and release. Indicate whether it is related to the input signal or to the feedback position signal.
Filters	If filters are provided, are they analogue or digital?
External (process) control	Can function blocks (according to IEC 61499) for an external control loop be implemented?
Special functions	Indicate if special functions are available (e.g. pressure sensor in actuator, leak detection, flow measurement).

Table 1 *(2 of 2)*

Function/capability	Aspects to be considered during evaluation
Valve diagnostics	Check whether implemented Valve Diagnostics cover the following aspects: – change in performance of control valve (dead band, resolution, etc.) – change of friction – wear of plug – wear of stem – packing leakage – seat leakage – break of stem – cavitation – broken actuator spring – air leakage at actuator – valve stuck – torn diaphragm at actuator – detection of reduction of performance by plugging of pneumatic Other aspects
Checks on extent of and tools for valve diagnostics	Check how the aspects mentioned above are diagnosed, tested, stored, reported and presented by the positioner or the host system. Does the diagnostic tool provide direct automatic interpretation by the instrument or does it require a specific level of human expertise. For each aspect check which of the tools (tests) mentioned below are used, check per tool the following points: – whether the diagnostic tests can be performed in-service – whether it is an on-line automatic test or an operator-initiated – check intervals between automatic tests – check user-adaptability of test parameters – check whether test affects the stem position – indicate whether data can be stored and where (local or in PC) – check whether there is a related direct alert/alarm message or whether it has to be deduced by the user from other information given by the positioner. (Example: Many positioners are equipped with a user-adjustable alarm indicating that the valve is not reaching its position in a certain time. Break of stem, and broken spring will most probably trigger this alarm) – check the action of the positioner on appearance of diagnostic alarms Tools (tests) that can be present are amongst other things: – high/low position alarms – rate of change alarm – cycle counter/accumulator – ravel accumulator – valve signature test – step response test – time to settle exceeds the set limit Accumulator for time close to zero

Table 2 – Configurability

Function/capability	Aspects to be considered during evaluation
Fieldbus compatibility	Check whether the instrument under test is suited for either: – HART®[1] – PROFIBUS PA[2] – PROFIBUS DP[2] – FOUNDATION™ FIELDBUS H1[3] – FOUNDATION™ FIELDBUS HSE[3] – Other (state details)
Configuration tools	Check if the instrument can be configured: – from local controls (human interface) on instrument – remotely from PC or a host computer – via handheld communication unit to be connected temporarily – other
On-line (re)configuration	Check whether parameters can be changed in control mode, if so whether the position of the valve stem is unacceptably affected. Check whether there is a security mechanism that prohibits on-line access to all or some parameters.
Off-line configuration	Check whether it is possible to set up and store configurations for a number of positioners on a separate (off-line) PC, which is not connected to a positioner.
Up/download to/from PC	Check if configuration upload is possible. Check if download of off-line prepared configurations is possible.
Configurable travel characteristics	Mention user-selectable characteristics that reside in the instrument, such as: – linear – equal percentage (IEC 60534-1) 1:50; 1:30; 1:25, etc. – equal percentage proprietary – quick opening – segmental (user defined travel characteristic), mention number of segments NOTE The equal percentage characteristic is sometimes realised by segmental approach. It is important to state the number of segments and their size and to evaluate the maximum errors with respect to the theoretical equal percentage characteristic.
Configurable “fail-safe” position	Check the availability of a configurable fail-safe position. Note the behaviour for the different failure modes. Use Table 6 to check behaviour.
Balance pressure	Check whether the balance pressure for the double acting version is user-adjustable.
Conditions on start-up after loss of power or an instrument reset	After a power down the user may want the positioner to return to a defined position. Positioners may be provided with: – return to last value – go to fail-safe – go to a user-defined value – return to control in manual mode

1 HART® is the trade name of the non-profit consortium HART Communication Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the products named. Equivalent products may be used if they can be shown to lead to the same results.

2 PROFIBUS PA and PROFIBUS DP are the trade names of products supplied by the non-profit organization PROFIBUS Nutzerorganisation e.V. (PNO). This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the products named. Equivalent products may be used if they can be shown to lead to the same results.

3 FOUNDATION™ FIELDBUS H1 and FOUNDATION™ FIELDBUS HSE are the trade names of products supplied by Fieldbus Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the products named. Equivalent products may be used if they can be shown to lead to the same results.

Table 3 – Hardware configuration

Function/capability		Aspects to be considered during evaluation
Robustness	Hinged covers	– Complexity and soundness of construction and protection against damage – Separate termination compartment – Availability of material of construction for severe service application (e.g. offshore, food) – Availability of integrated pneumatic connections – Availability of quick connect provisions for electrical and pneumatic connections – Isolation of pneumatic and electronic compartments
	Valve position feedback mechanism	
	Internal modules	
	Support to valve	
	Protruding parts	
	Local controls	
	Electrical connections	
	Pneumatic connections	
Remote position sensor		Check the availability of a remote position sensor that provides mechanical separation of the electronics and comment on soundness and ease of installation and calibration.

Table 4 – Operability

Function/capability	Aspects to be considered during evaluation
Local controls (tools) for access	Give a concise description of: – available controls (pushbuttons, etc.) – accessibility – ergonomic layout and use of the controls – can controls be used in hazardous locations?
Local displays	Give a concise description of data that can be shown on the local displays: – number of lines and characters per line – control parameters given – error messages, etc. Is display readable without removing covers?
Human interface at external system	Give a concise description of the organisation and hierarchy of the various user access groups and related displays in the PC based software. Give for a handheld communicator a picture with layout of display and keyboard.
Other points for human interaction	List other hardware tools (switches, potmeters, etc.) and the related parameters they control.

Table 5 – Dependability *(1 of 2)*

Function/capability	Aspects to be considered during evaluation
Positioner diagnostics	Describe in short the extent of the system for diagnosing internal positioner failures and securing safe operation in case of failures. Mechanisms may be implemented for detecting: – memory failure – no free time – reference voltage failure – input current out of range – critical NVM failure – temperature sensor failure – pressure sensor failure – travel feedback sensor failure Fieldbus devices may provide specific messages such as: – I/O processor fault – output not running – static parameters lost – calibration data read error Check which diagnostics are performed: – on-line (in service) automatically, continuously or intermittently – on-line (in service) user-initiated – offline (out of service) Does the manufacturer provide a coverage factor with respect to detection of internal failures?
Alarms	Basically two groups of alarm types can be distinguished: – Process alarms (related to the above mentioned valve diagnostic aspects and the valve/actuator condition). Alarm settings may be user-adjustable. – Selftest alarms (related to above mentioned positioner diagnostics on internal electrical failures). These alarms are in general not user-accessible. • Which alarms in both groups are provided? • How do they communicate? i) hard wired via relay outputs ii) on local display iii) via fieldbus – Do alarms appear automatically or only on user request?
Security against unauthorised access	Describe method of implementation of security: – hardware (write protect switch) – software (passwords, number of access levels and the degrees of access and configurability at these levels) Access to local controls

Table 5 *(2 of 2)*

Function/capability	Aspects to be considered during evaluation
Maintainability	What level of repair does the manufacturer specify? (exchange of parts, exchange of complete instrument) Determine time to repair comprising of replacement in workshop including configuration, calibration and tuning. What tools are required for maintenance? Are preventive maintenance methods defined? Are predictive maintenance methods defined? Can the positioner be exchanged when the valve is in an on-line system?
Reliability	Is MTBF-figure provided and what is its source: – public or proprietary database such as MIL HDBK 217 – field experience (look for population over which figures are calculated and period of data collection) Is partial or complete redundancy provided or optionally available?

Table 6 – Fail safe behaviour

	Positioner venting	Positioner filling	Positioner holding last position	Positioner holding other position
Supply pressure failure				
Set point failure				
Auxiliary power failure				

4.3.2 Reporting

The reporting format follows exactly the structure given in 4.3.1

Table 7 – Reporting

Function/capability	Observations and comments
Fieldbus	
Configuration tools	
On-line reconfiguration	
Off-line configuration	
Up/download to/from PC	
Configurable travel characteristics	
Etc.	

4.4 Documentary information

Table 8 summarises the relevant subjects which shall be checked for availability in the manufacturer's documentation.

Table 8 – Document information

Subject	Observations and comments
Instrument identification – Tag or nameplate on enclosure – Software identification	
Operating principle	
Weight and dimensions	
Application limits – Temperature – Vibration – Humidity – EMC – Environmental protection – Power supply	
Environmental classification (IEC 60721-3) Operating conditions (IEC 60654)	
Safety – Hazardous areas certification	
Dependability – Failure rates	
Mechanical construction – Envelope dimensions, mounting – Housing and wetted materials and coating	
External wiring diagrams	
Software description – Software version – Firmware version	
Mounting instructions	
Configuration instructions and tools	
Commissioning – Adjustments – Calibration – Tuning/initialisation	
Operating instructions	
Self-testing/troubleshooting	
Maintenance instructions	
Performance specifications	
Spare parts list	
Ordering information	
Manufacturer support facilities	

When this information is not available or adequate, it shall be stated in the column "Observations and comments".

Moreover, the adequacy of the methods of identification of the positioner via a tag or shield on the enclosure and in the software shall be described.

5 Performance testing

5.1 General

The performance testing of an intelligent valve positioner is executed with the positioner mounted on an agreed actuator/valve assembly. The relevant parameters of the combination such as stroke, friction (hysteresis), type of packing, spring package and supply pressure for the pneumatic part, are to be carefully chosen (see 5.2.2) and reported.

Prior to starting the tests, the positioner shall be adjusted, calibrated and tuned according to the manufacturer's instructions.

5.2 Reference conditions for performance tests

5.2.1 Overview

The reference values for the environmental and operational test conditions shall be as stated in Clause 6 of IEC 61298-1:2008 and Clause 4 of IEC 61514:2000.

Tests shall preferably be carried out within the specified reference atmospheric conditions. They may exceptionally be carried out within the recommended limits; however, they shall in no case exceed these limits. When measurements within the recommended limits are unsatisfactory, they shall be repeated under the reference atmospheric conditions.

The choice of the valve/actuator assembly is subject to negotiations between the parties involved in an evaluation. They shall also take into account the considerations in 5.2.2. In case the evaluation aims at comparing a variety of different makes of positioners, the various makes shall be tested on identical valve/actuator assemblies. Then also the relevant parameters mentioned in 5.2.2 shall be identical for the various makes.

The tests will be performed with a friction force of 10 % (see 5.2.2) with the exception of environmental tests (temperature, humidity, EMC) and the vibration test will be performed with only a minimal friction force sufficient to give stable operation.

The size of pneumatic connections and tubing shall be as recommended by the manufacturer and shall be stated in the report. The parties involved may agree on different sizes.

The pneumatic supply source shall be capable of maintaining the supply pressure within ±10 kPa during dynamic and airflow tests.

The capabilities of a design are best highlighted in one or more applications with extreme requirements. To achieve such applications the considerations of 5.2.2 shall be taken into account regarding the relevant parameters of the valve/actuator assemblies. These considerations are equally valid for linear stroke and rotary valve/actuator assemblies.

Before each test the evaluator shall take care that the instrument is in an error- and fault-free state and in the normal operational mode. Prior to each test then reference measurements are performed to determine shifts of the various relevant quantities during and after that test.

5.2.2 Valve characteristics

5.2.2.1 General

The type of valve – either linear stroke or rotary, single- or double-acting – is subject to agreement between the parties involved.

5.2.2.2 Actuator/valve size

The valve, actuator and mounting kit used in the test setup have to be documented.

The following parameters have to be mentioned as a minimum:

- effective diaphragm size;
- travel range/rotation angle;
- friction force;
- spring force range.

5.2.2.3 Travel

The travel adjustment shall be performed according to the manufacturer's documented procedures (automatic, manual or a mix).

5.2.2.4 Travel characteristic

Unless otherwise stated the evaluation shall be performed with the linear characteristic implemented in the positioner. Accuracy measurements may also be performed at the other available characteristics such as equal percentage. When evaluating the characteristic before the accuracy measurements the evaluator shall have to report possible zero errors that may be due to the above mentioned adjustment procedures.

5.2.2.5 Actuator bench set

NOTE Double acting actuators do not necessarily require a spring package for proper operation.

The actuator spring package shall preferably be chosen in a range of approximately 40 kPa to 200 kPa. In combination with a high supply pressure the dynamic behaviour in upward and downward directions is considerably different for single-acting positioners. Moreover, the process is also strongly non-linear. Thus, obtaining stable control over the whole travel range may be a challenging request to the implemented (automatic) stem tuning procedures.

5.2.2.6 Packing

Unless otherwise agreed between the parties involved, the evaluation shall be performed with a valve/actuator assembly that is equipped with standard PTFE packing. The parties involved may agree on other types of packing such as graphite. The characteristic friction forces of graphite pose a greater demand on the control capability of a positioner. When the actuator/ valve assembly has been used previously, the evaluator has to make sure that a new set of packing is installed prior to the start of the evaluation.

5.2.2.7 Friction force

The breakout friction force for valves equipped with a single acting actuator shall preferably be adjusted to cause a dead band of 5 % to10 % of travel at start-up of the evaluation. For valves with a double acting actuator (not spring-opposed) it shall preferably be adjusted to cause a dead band of 5 % to10 % of the agreed supply pressure at start-up of the evaluation. The parties involved may agree upon other values. The friction force is a large contributor to the non-linearity of the process of controlling a valve/actuator assembly. Note the adjustment procedure for the purpose of the evaluation. The friction force shall also be measured at the end of the evaluation.

5.2.2.8 Supply pressure

The supply pressure shall be set to a relatively high value in the specified range (recommended 240 kPa for single acting actuators and 400 kPa for double acting actuators).

NOTE The given supply pressure values are only typical values. They are adapted to the actual valve size according to the valve manufacturer's recommendation.

In combination with a bench set in the low range (e.g. 40 kPa to 200 kPa) the dynamic responses of a single acting actuator in the upward and downward directions are quite different at much higher supply pressures. In the upward direction the driving force (the difference between supply and actuator pressures) is much larger than the driving force in the downward direction (the difference between actuator pressure and barometric pressure). Moreover, the airflow in tubing and restrictions at different pressures is far from linear. This poses a great demand on the stem tuning procedures that has to provide optimal control parameters for stability and valve controllability.

5.3 General testing procedures

5.3.1 Test set-up

Figure 4 gives the basic test set-up. The evaluation requires the following instruments:

- Travel measurement

  For the accuracy measurements of the travel characteristic a travel transducer shall be used with an uncertainty 10 times better than the specified accuracy or < 0,05 % of travel. For the dynamic tests and the environmental tests a calibrated high stability linear potentiometer may be used. The devices shall be rigidly mounted on the valve/actuator assembly and they shall be connected parallel and hysteresis-free to the valve stem. The accuracy errors and shifts due to the applied tests shall be expressed in % of the calibrated travel.

- Input signal generator

  For positioners with an mA input circuit a suitable mA signal generator is required with an uncertainty of <0,01 % of span.

  For fieldbus positioners the manufacturer provides the evaluator with the necessary hardware and software and instructions for use. In that case the mA input circuit is not available and data is entered via the communication interface shown in Figure 1. Prior to positioner testing the dynamic effects of this fieldbus system shall be mapped and taken into account for the dynamic positioner tests. For this purpose a bus monitor might be included.

  The accuracy errors and shifts due to the applied tests shall be expressed in % of span.

- Auxiliary inputs

  When an auxiliary sensor is integrated in the positioner the actual quantity to be measured has to be applied. When the sensor is not provided in the positioner an electrical signal equivalent to the sensor output signal shall be applied. The signal generators to be used shall have an accuracy preferably 10 times but at least 4 times better than the accuracy specified by the manufacturer for the circuit to be considered.

  The accuracy errors and shifts due to the applied tests shall be expressed in % of span.

- Auxiliary outputs

  The analogue auxiliary output circuit shall be supplied and loaded as described by the manufacturer. Measurements shall be performed with equipment with an overall accuracy preferably 10 times but at least 4 times better than the accuracy specified by the manufacturer.

  The accuracy errors and shifts due to the applied tests shall be expressed in % of span.

  For digital relay outputs the circuits shall be powered and loaded as specified or recommended by the manufacturer.

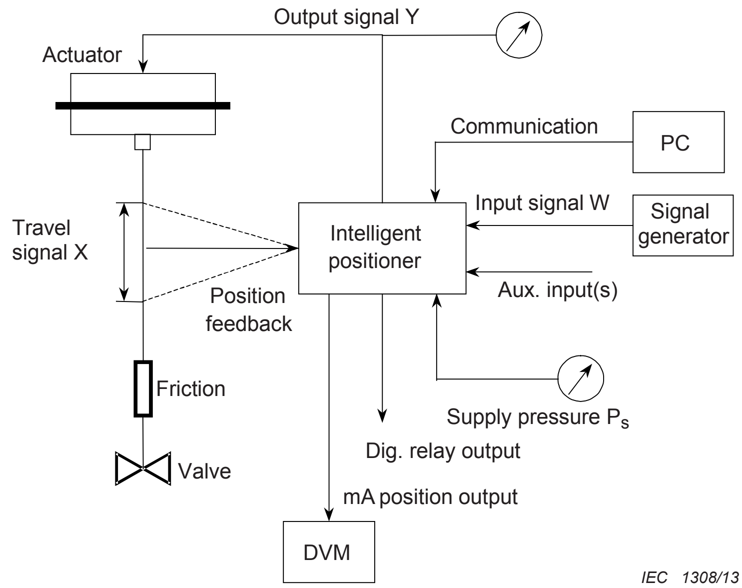

Figure 4 – Basic test set-up

5.3.2 Testing precautions

Besides the testing precautions mentioned in 5.3 of IEC 61514:2000 the following shall also be taken into consideration for the evaluation of an intelligent valve positioner.

Prior to starting the tests the instrument shall be calibrated and tuned in accordance with the methods provided and described by the manufacturer. The instrument shall then with a stationary input provide a stable position of the valve. In case of instability the manufacturer may be consulted.

The manufacturer shall explicitly state which tests may cause damage. These tests will not be performed unless permitted.

5.4 Initial observations and measurements

5.4.1 Overview

In general, report on mechanical problems that may have appeared during any test.

5.4.2 Mounting procedure

The mounting procedure may be part of the calibration and linearisation procedure. Note the ease of mounting and any difficulties with the mechanical linkage calibration and tuning that may have appeared when dismounting and mounting the instrument.

Also determine the time needed for correct mounting.

5.4.3 Configuration procedures

Report difficulties that appeared when configuring the instrument. Difficulties could be amongst other things:

– Incorrect entries due to too small distance between keys.
– Some parameter entries may automatically and unnoticeably change other parameters.
– Inconsistencies in handling parameters such as no warning messages when trying to change a protected parameter.

Measure the time required for off-line configuration.

Measure the time required to up- or download a configuration to/from a PC.

5.4.4 Stem position calibration procedure

The following aspects of the calibration procedure have to be considered:

Mechanical connection if any and linking to the valve.

- Is the procedure automatically performed after the start?
- If not, how many times has the user to interact and when?
- Is the stem calibration procedure used for benchmarking (e.g. determination of friction, dead band, etc.)?
- Are calibration data (name operator, date, parameters, etc.) stored in non-volatile memory?
- Are external gauges required?

Tools required to calibrate the instrument.

- Are there travel restrictions and/or limitations (can zero and span be adjusted to any value between the full stops)?
- What is the resolution of zero/span adjustments?
- Measure the time required for calibration.
- How is linearisation at linear stroke actuators realised?

Note any difficulties that appeared when performing the procedure. Linearisation may be difficult when it requires the user to loosen and move the positioner with bracket to search for an optimal position with respect to the actuator/valve assembly.

5.4.5 Stem position tuning procedure

Describe the tuning method succinctly:

- Is it a fully automatic procedure, if not, how many times is user interaction required during execution?
- Does automatic tuning lead to stable control?
- Are parameters automatically activated or can user ignore/change them and fill in different values?
- Are tuning and calibration integrated inseparably in one procedure?
- Measure the time required for tuning.
- Does the tuning procedure automatically update the control parameters in-service?

5.5 Performance test procedures

5.5.1 General

Table 9 below gives an overview of a test done under reference conditions.

Table 9 – Test under reference conditions *(1 of 3)*

<table>
<tr><th>Designation</th><th>Notes on test methods and on information to be reported</th><th>Reference</th><th>Additional information</th></tr>
<tr><td>• Accuracy</td><td></td><td></td><td></td></tr>
<tr><td>• Terminal-based linearity errors linear characteristic
• Hysteresis
• Repeatability</td><td>Measurements at least 3 times in upward and downward directions at 10 % to 20 % intervals. Data shall be plotted in a graph.</td><td>IEC 61298-2:2008, Clause 4</td><td></td></tr>
<tr><td rowspan="2">• Conformity errors equal percentage characteristic
• Hysteresis
• Repeatability</td><td>Measurements at least 3 times in upward and downward directions at predefined intervals. Data shall be plotted in a graph.</td><td></td><td></td></tr>
<tr><td colspan="3">In case the travel characteristic shall also be determined for the equal percentage characteristic the manufacturer shall explicitly state how calibration and tuning are to be performed. Carefully check the stability over the full travel range in particular when no specific stem tuning procedure for the equal percentage characteristic is provided. Travel measurements shall be done at the following input settings: 0 %, 5 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 %, 70 %, 75 %, 80 %, 85 %, 90 %, 95 %, 98 %, 100 %. The output values are calculated with the following formula for the equal percentage curve stated in IEC 60534-1:

$$\Phi = \Phi_0 \times e^{nh}$$
where
Φ is the relative flow coefficient;
Φ_0 is the relative flow coefficient corresponding to h = 0;
n is the slope of the inherent equal percentage flow characteristic when logΦ is plotted against h;
h is the relative travel.

The following error curves will be plotted:
– Measurements against the manufacturer’s implemented curve
– Measurements against the above given equal percentage (IEC) curve</td></tr>
<tr><td rowspan="2">• Linearity errors analogue feedback output
• Hysteresis
• Repeatability</td><td>Measurements at least 3 times in upward and downward direction at 10 % to 20 % intervals.

Data shall be plotted in a graph.</td><td>IEC 61298-2:2008, Clause 4</td><td>Optional test in case analogue feedback output is provided</td></tr>
<tr><td colspan="3">Report clearly which characteristics have been determined as the analogue feedback output signal may be available as:
– The displayed output of the feedback sensor on PC or local display.
– A mA output of an electrically isolated transmitter integrated in the positioner.</td></tr>
<tr><td>• Linearity errors auxiliary sensors
• Hysteresis
• Repeatability</td><td>Measurements at least 3 times in upward and downward direction at 10 % to 20 % intervals.

Data shall be plotted in a graph.</td><td>IEC 61298-2:2008, Clause 4</td><td>Test may be skipped when sensors are not essential for correct operation</td></tr>
<tr><td>• Switching points digital inputs sensor</td><td>Determine threshold values for switching from logic “0” to “1” and reverse</td><td></td><td>Optional test</td></tr>
</table>

Table 9 *(2 of 3)*

Designation	Notes on test methods and on information to be reported	Reference	Additional information
• **Dead band**	Measurement at 50 % (10 % and 90 % optional)	IEC 61298-2:2008, 4.2	Positioners with a pulsed output (Figure 3) need dead band for stable operation
	When adjustable it shall be measured at the value required for optimal and stable control (as advised by the manufacturer in the manual).		
• **Balance pressure**	Measurement of the balance pressure at 50 %	IEC 61514-2:2013, 3.12	Measurement at 10 % and 90 % is optional
	The test is only applicable for double acting positioners and it shall be executed in steady position. The value of the balance pressure shall also be expressed as a percentage of the positioner supply pressure.		
• **Dynamic response**			
• **Frequency response**	Put the setpoint at 50 % then apply a sinusoidal signal with an amplitude < 5 %, starting at 0,01 Hz and up to 3 Hz. Report: –3 dB point (relative gain 0,7); phase lag 45° and 90°; maximum relative gain and corresponding frequency and phase lag.	IEC 61514:2000, 6.10.3	
	The dynamic behaviour of the positioner/actuator/valve assembly is strongly affected by the supply pressure and the characteristics of the chosen actuator/valve assembly (size, nominal effective area, volume, spring package, friction). The results of dynamic tests are valid only for the assembly used for the test. For fieldbus instruments the test results will include the dynamic behaviour of the fieldbus. In that case perform the test until a frequency not >0,2 times the sample frequency.		
• **Step response**	Apply successively both in up- and downward direction at least 3 steps of 0,25 %; 0,5 %; 1 %; 2 %; 4 %; 8 %; 16 %; 32 % centered at 50 % setpoint. Repeat the test at 8 % step from 6 % to 14 % and 84 % to 96 % and in opposite direction. Determine step response time, dead time, overshoot and settling time 1 (as far as applicable) and settling time 2 as shown in Figure 5.	IEC 61514:2000, 6.10.4	See Figure 5
	For fieldbus-related positioners the transducer at the signal generator side (see Figure 4) should include a bus monitor for determination of the exact time at which the step function arrives at the instrument's input. Settling time 1: time for travel to reach and remain within 1 % of span of its final steady state value. Settling time 2: time for travel to reach and remain within 0,1 % of span of its final steady state value. Time constant: (63 % of final steady state value). For each type of step the average will be determined unless the mutual differences are >30 % or >2 s, whichever is the greatest. In that case the minimum and maximum values will be reported. Also report possible limit cycling. The test may be repeated with different supply pressures in combination with (auto)tuning and with different size pneumatic connectors and tubing.		
• **Airflow characteristic**	Determine the maximum delivered and exhausted flows (resp. $Q_{1\ max}$ and $Q_{2\ max}$).	IEC 61514:2000, 6.5.1	
	The test may be repeated with different supply pressures in combination with (auto-)tuning and with different size pneumatic connectors and tubing.		

Table 9 *(3 of 3)*

Designation	Notes on test methods and on information to be reported	Reference	Additional information
• **Steady-state air consumption**	Vary the input over the full travel and determine the point of maximum steady state air consumption	IEC 61514: 2000, 6.5.2	
• **Power requirements**	Determine the max. power consumption and valve position at which it appears		
	For loop-powered analogue (4 mA to 20 mA) positioners determine the voltage over the terminals at 100 % input. The manufacturer's specification for minimum current and voltage should be verified. For fieldbus the valve should be in movement. Power consumption during power-up.		

Figure 5 gives examples of step responses of positioners.

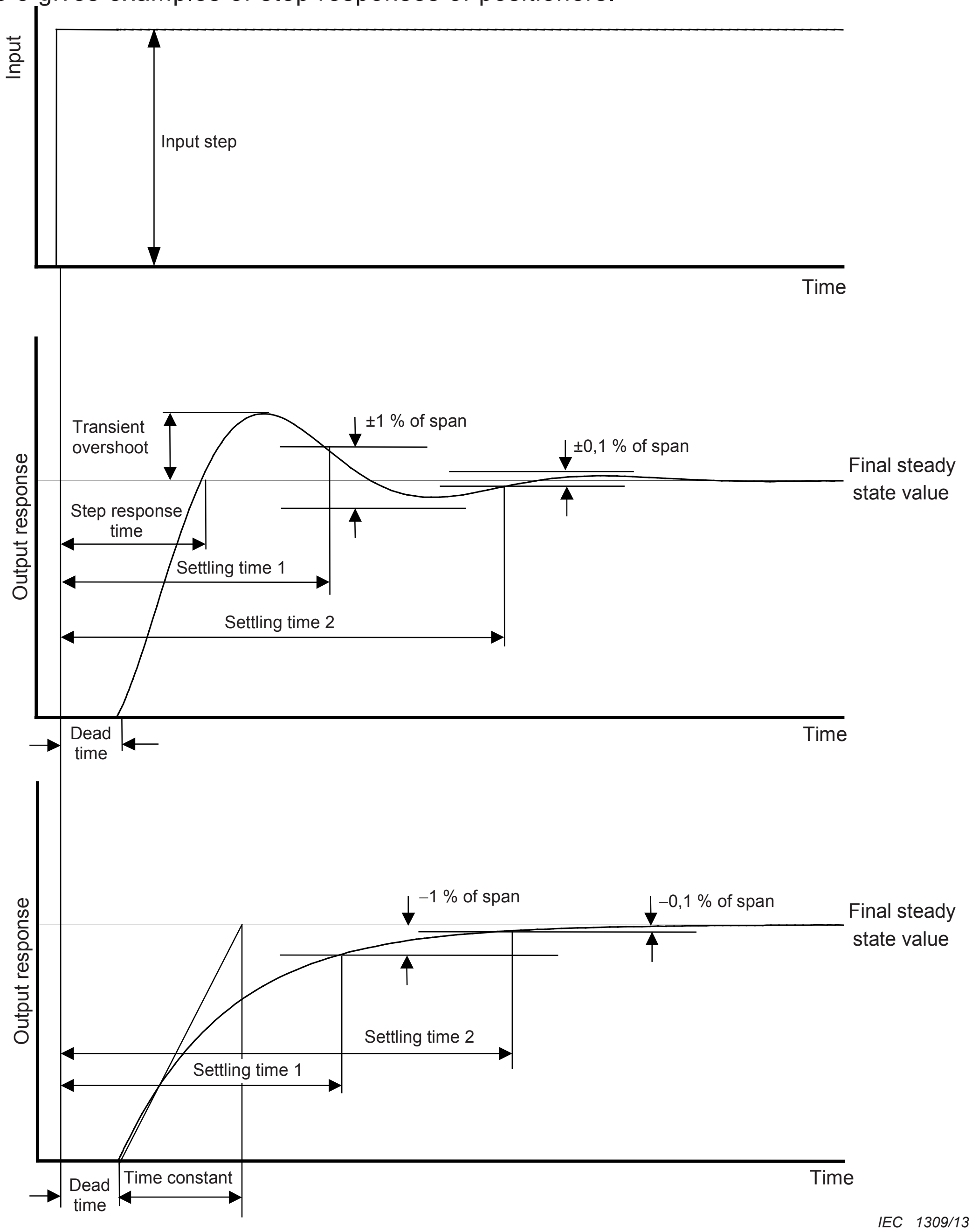

Figure 5 – Examples of step responses of positioners

5.5.2 Effects of influence quantities

The following matrix (Table 10) shows the observations and measurements to be performed and the test procedures to be executed to determine the effects of the influence quantities.

The following symbols are used in Table 10:

z/s Measurement of zero shift and span shift. During the conditioning periods between measurements the input signal will be kept constant at approximately 50 % and the travel signal shall be recorded.

NOTE Zero and span are derived from measurements at 5 % and 95 %.

50 Measurement at 50 %. In most cases the evaluator shall also measure amplitude and duration of transients and possible instability of travel and position output.

90 Measurement at 90 %. In most cases the evaluator shall also measure amplitude and duration of transients and possible instability of travel and position output.

10/90 Measurements at successively 10 % and 90 %.

X Observation shall be performed.

As the measurements and observations during and after each test are not always the same Table 10 distinguishes two situations indicated in the column "Time of measurement".

D = measurements and observations during test.

A = measurements and observations after test.

Table 10 – Matrix of instrument properties and tests *(1 of 6)*

Designation	Measurements and observations													Test procedures	Reference
		Accuracy[a]				Dependability[b]					Stability[c]				
	Time of measurement	Travel characteristic	An. feedback output	Further aux. I/O	Intermediate values	Damage/failure	Softw. configuration	Communication	Local display	Diagn. messages	Step response	Stability	Initialisation	Notes on test methods and information to be reported	Reference
Supply pressure	D	z/s								X	X	X	X	Vary supply pressure from agreed reference value to minimum and maximum manufacturer's specified values. On substantial effects do test at intermediate values	IEC 61514: 2000
	A	z/s								X		X	X		
Ambient temperature: performance	D	z/s	z/s	z/s	X	X	X	X	X	X	X	X		Submit assembly two times to +20 °C, +40 °C, +60 °C, +85 °C, +20 °C, 0 °C, –20 °C, –40 °C, +20 °C but do not exceed manufacturer's specified limits	IEC 61298-3: 2008, Clause 5 IEC 60068-2-1, IEC 60068-2-2
	A	z/s	z/s	z/s	X	X	X	X	X	X	X	X			
Ambient temperature: operability	D											X	X	Check for correct cold start-up	
	A											X	X		
	The positioner/actuator assembly will be submitted for at least 6 h to respectively the minimum and maximum manufacturer's specified temperatures with power and air supply switched off. The power will then be switched on and the instrument will be checked for correct start-up. After correct start up perform position measurements at 5 % and 95 % input. Then perform the initialisation procedure as described by the manufacturer (in many cases the "auto-tuning" procedure). Any differences with respect to initialisation at room temperature will be reported. These may be: – different parameters, – increased time for performing the procedure.														
Relative humidity	D	z/s	z/s	z/s	X			X	X					40 °C ± 2°C, 93 % RH +2 %/–3 % during 48 h	IEC61298-3: 2008, Clause 6 IEC 60068-2-78
	A	z/s	z/s	z/s	X	X		X	X						
	The positioner shall be submitted within 2 h to 40 °C ± 2 °C and 93 % + 2 %/–3 % RH and shall be maintained for at least 48 h at these conditions. During the initial 4 h and the final 4 h of this period the instrument will be powered. In between the power will be switched off. After the 48 h period the relative humidity and temperature will be lowered in 2 h to and kept for at least 4 h at reference atmospheric conditions. Measurements and observations will be performed: – At the end of the initial 4 h, when still under power. – Directly after powering up the positioner in the final 4 h period. – At the end of the final 4 h at elevated temperature and humidity. – At the end of the 4 h period after the test at reference atmospheric conditions.														
Mounting position	D	z/s	z/s											Tilt assembly over ± 10° and ± 0° in 2 mutually perpendicular planes from reference position	IEC 61298-3:2008, , Clause 9
	A	z/s	z/s												

Table 10 *(2 of 6)*

<table>
<tr><th rowspan="3">Designation</th><th colspan="13">Measurements and observations</th><th>Test procedures</th><th rowspan="3">Reference</th></tr>
<tr><th rowspan="2">Time of measurement</th><th colspan="4">Accuracy[a]</th><th colspan="5">Dependability[b]</th><th colspan="3">Stability[c]</th><th rowspan="2">Notes on test methods and information to be reported</th></tr>
<tr><th>Travel characteristic</th><th>An. feedback output</th><th>Further aux. I/O</th><th>Intermediate values</th><th>Damage/failure</th><th>Softw. configuration</th><th>Communication</th><th>Local display</th><th>Diagn. messages</th><th>Step response</th><th>Stability</th><th>Initialisation</th></tr>
<tr><td rowspan="3">Drop and topple</td><td>D</td><td>50</td><td>50</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td><td rowspan="2">IEC 61298-3:2008, Clause 8
IEC 60068-2-31</td></tr>
<tr><td>A</td><td>50</td><td>50</td><td></td><td></td><td>X</td><td></td><td></td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="15">For this test, the positioner is removed from the valve/actuator assembly and the feedback lever is fixed at a position corresponding to 50 %. The positioner will be standing in its normal position of use, on a smooth, rigid surface of concrete or steel. It shall be subjected to one drop about each of the four bottom edges. The positioner is tilted over one bottom edge until distance between the opposite edge and the test surface is either 25 mm, 50 mm, or 100 mm or 30° angle, whichever is the less severe condition. It is then allowed to fall freely on to the test surface.</td></tr>
<tr><td rowspan="3">Mechanical vibration</td><td>D</td><td>50</td><td>50</td><td>50</td><td></td><td>X</td><td></td><td>X</td><td>X</td><td>X</td><td></td><td>X</td><td></td><td rowspan="2">Test complete assembly from 10 Hz to 500 Hz at ampl. of 0,15 mm (10 Hz to 60 Hz) or 2 g (60 Hz to 500 Hz) in 3 directions as described below</td><td rowspan="2">IEC 61298-3: 2008, Clause 7
IEC 60068-2-6
see Annex A</td></tr>
<tr><td>A</td><td>z/s</td><td>z/s</td><td>z/s</td><td></td><td>X</td><td></td><td>X</td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="15">Test preparations
The positioner/actuator assembly shall be mounted and tightly fixed as shown in Annex A with a set of rigid brackets on the test table of the vibration machine. Then subject the assembly to vibrations in three mutually perpendicular axes in turn. The reference (control) accelerometer shall be mounted on the table and a second (response) accelerometer will be mounted on the positioner, both measuring in the vibration direction. The travel and analogue feedback output and the amplitude ratio Q between the two accelerometers shall be recorded as a function of the vibration frequency. Before and after each stage measurements of zero and span shall be performed.
Test description
The test consists in each direction of a test level of 0,15 mm/19,6 m/s^2 = 2 g (field application on pipe-line with low vibration (IEC 61298-3):
First stage: initial resonance search
During this stage the instrument shall be operated with a steady input signal of 50 %. The stem position and the above-mentioned amplitude ratio will be recorded as a function of the vibration frequency. Determine frequency ranges at which amplitude ratio $Q > 2$ for comparison with those found during the final resonance search specified below.
Second stage: endurance at critical frequency
From Q-record determine frequency causing the highest resonance peak at the lowest frequency. Then vibrate assembly at this frequency for 30 min. During this stage the instrument shall be operated with a steady input signal of 50 %. The stem position shall be recorded as a function of the vibration frequency.
Third stage: final resonance search
The final resonance search shall be made identical to the initial resonance search. Any significant differences in performance at 50 % input, changes of resonance peaks and changes in frequency ranges with $Q > 2$ with respect to the initial resonance search shall be noted.</td></tr>
</table>

Table 10 *(3 of 6)*

Designation	Measurements and observations													Test procedures	Reference
		Accuracy[a]				Dependability[b]					Stability[c]				
	Time of measurement	Travel characteristic	An. feedback output	Further aux. I/O	Intermediate values	Damage/failure	Softw. configuration	Communication	Local display	Diagn. messages	Step response	Stability	Initialisation	**Notes on test methods and information to be reported**	
Power freq. magnetic field	D	z/s	z/s	z/s		X		X	X	X		X		Test level shall be 30 A/m	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X		X	X	X		X			
Radiated interference	D	50	50	50		X	X	X	X	X		X		Test level shall be 10 V/m, in frequency range from 80 MHz to 1 000 MHz with an amplitude-modulated signal (1 kHz sine wave, modulation 80 %) superimposed on the carrier wave. During the test the relevant signals shall be recorded	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X	X	X	X	X		X			
Conducted disturbances	D	50	50	50		X	X	X	X	X		X		Test level shall be 3 V. During the test the relevant signals shall be recorded	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X	X	X	X	X		X			
Electrical fast transients	D	50	50	50		X	X	X	X	X		X		Test shall be applied only when connecting lines are >3 m at 1 kV test level	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X	X	X	X	X		X			
	When the positioner is equipped with separate circuits for power supply the test shall also be applied to these circuits at levels of respectively 2 kV direct injection.														
Surge voltage immunity	D	50	50	50		X	X	X	X	X		X		Test shall be applied only to long-distance lines at 1 kV test level	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X	X	X	X	X		X			
	When the positioner is equipped with separate circuits for power supply the test shall also be applied to these circuits at levels of respectively 1 kV (line-to-line) and 2kV (line-to-ground).														
Electrostatic discharges	D	50	50	50		X	X	X	X	X		X		Test shall be performed at Class III level: – Contact: discharges 4 kV – Air discharges 8 kV	IEC 61326-1: 2012, Table 2
	A	z/s	z/s	z/s		X	X	X	X	X		X			
Common mode interference	D	50	50			X		X				X		Apply in turn to + and – wires of isolated I/O and supply circuits: – 250 V a.c. – +50 V d.c. and –50 V d.c.	IEC 61298-3: 2008, 13.1
	A	50	50			X		X				X			
Series mode interference	D	50	50					X		X		X		Apply series mode signal to input circuit(s). Determine signal level at which position effects are >0,5 % of span	IEC 61298-3: 2008, 13.2
	A	50	50					X		X		X			
	The series mode signal shall not be >1 V (volt inputs) or > 10 % of span (current input).														

Table 10 *(4 of 6)*

Designation	Measurements and observations													Test procedures	Reference
		Accuracy[a]				Dependability[b]					Stability[c]				
	Time of measurement	Travel characteristic	An. feedback output	Further aux. I/O	Intermediate values	Damage/failure	Softw. configuration	Communication	Local display	Diagn. messages	Step response	Stability	Initialisation	**Notes on test methods and information to be reported**	
Input over-range	D	X	X			X				X		X		Apply a voltage of 24 V d.c. to input terminals for 1 min. Observe the behaviour of the positioner during overload period. After 5 min recovery at 50 % input, measurements and observations will be performed on remaining effects	IEC 61298-3: 2008, Clause 10
	A	z/s	z/s			X				X		X			
	In case the positioner is connected to a source that uses another voltage than 24 V the test level shall be adapted accordingly. This test may be damaging to the positioner under test, it should preferably be performed as the last test and only if the manufacturer agrees on the test being performed.														
Power supply variation	D	z/s	z/s			X		X	X	X		X		– a.c. supply: +10 %/–15 % voltage variation; ± 2 % and ± 10 % frequency variation – d.c. supply: +20 %/–15 % Perform measurements and observation at each variation	IEC 61298-3: 2008, 12.1
	A	z/s	z/s			X		X	X	X		X			
	Eventually the test can be extended to wider variation on to specified limits.														
Power interruptions	D	90	90			X		X	X	X		X		Interrupt power for 5 ms; 20 ms; 50 ms; 100 ms; 200 ms and 500 ms. Record travel signal and observe behaviour on return of the power	IEC 61298-3: 2008, 12.4 IEC 61000-4-11
	A	90	90			X		X	X	X		X			
	Report transient on travel, total time of distortion, time to recover original position and possible difficulty to restart. Perform at least 10 interrupts at each setting.														
Start-up drift	D	10/ 90	10/ 90									X		Test to be performed at 10 % and 90 % respectively both after power has been switched off for 12 h	IEC 61298-2: 2008, 7.1
	A	10/ 90	10/ 90									X			
Long-term drift	D	90	90	90		X		X	X	X		X		Measurements over 30 days at 90 % input	IEC 61298-2: 2008, 7.2
	A	z/s	z/s	z/ s		X		X	X	X		X			
Accelerated life test	D	z/s	z/s		X	X		X	X	X		X		100 kcycles with sinusoidal input between 5 % and 95 % at a frequency at which attenuation is not < 0,95. Perform measurements and observations after 5; 10; 20; 40; 60; 80 and 100 kcycles. Report any malfunction during the test period together with the number of cycles completed	IEC 61298-3: 2008, Clause 23
	A	z/s	z/s		X	X		X	X	X		X			

Table 10 *(5 of 6)*

Designation	Measurements and observations													Test procedures	Reference
		Accuracy[1]				Dependability[2]					Stability[3]				
	Time of measurement	Travel characteristic	An. feedback output	Further aux. I/O	Intermediate values	Damage/failure	Softw. configuration	Communication	Local display	Diagn. messages	Step response	Stability	Initialisation	Notes on test methods and information to be reported	
Air leakage at actuator	D	50	50							X		X		Introduce in the tubing/piping between positioner and actuator air leakage at successively steady flow rates of 50 Nl/h and 500 Nl/h.	
	A	50	50							X		X			

a **Accuracy**

Travel characteristic

For the travel characteristic of the instrument under test the input has to be successively adjusted to values of 5 % and 95 % under the various test conditions and before and after the test, and the corresponding positions shall be measured.

Zero and span are derived from measurements at 5 % and 95 %. Preferably the travel signal shall be recorded.

Analogue feedback output

The analogue feedback output as far as available at the positioner under test will be measured. It will be done at input values to the positioner of 5 % and 95 % under the various test conditions and before and after the test and the resulting zero shift and span shift will be determined from these measurements. Preferably the position output signal shall be recorded.

Auxiliary I/O

For the auxiliary sensors as far as they are available at the instrument under test the relevant quantity has to be applied at values of 0 % and 100 % under the various test conditions and before and after the test and the resulting zero shift and span shift will be determined. Auxiliary sensors (see also Figure 1) may be provided for:

- Positioner output pressure.
- Upstream line pressure.
- Differential pressure.
- Stuffing box leakage detector.

Digital inputs are checked for correct operation by introducing successively a logic "0" and a logic "1".

Digital outputs are checked for correct switching from "0" to "1" and back upon application of the relevant stimulus.

Intermediate/internal values

When the instrument has facilities for reading on local display or PC intermediate values of input quantities these shall also be monitored and noted. In case of failures or errors these data may show in which part they occurred. We think of:

- The converted (digitised) mA signal.
- The feedback sensor signal.
- Internal temperature.

b **Dependability**

Hardware damage

Observe during and/or after the test the instrument for obvious mechanical damage.

Software configuration

Check the software configuration with respect to user accessible data for any damage or change due to the applied test condition.

Communication

Check the communication via local controls (readability of displays and correct operation local keyboard or pushbuttons) and remotely with handheld terminal or PC.

When the instrument is operating real-time in a fieldbus also check the communication for delays or temporary stops as a result of the applied test.

Table 10 *(6 of 6)*

	Diagnostic messages
	Check diagnostic displays (local and at PC or handheld terminal) and report diagnostic messages and process alarms that may appear as a result of the applied test condition. Instruments may be equipped with a variety of diagnostic tests that can be run either automatically or initiated by the operator in a healthy or a faulty instrument. In case the instrument is not fully operating as expected, the evaluator shall check the operation of the instrument with these diagnostic facilities.
c	**Stability**
	Step response
	Introduce steps from 45 % to 55 % and back and report any change in time to reach a stable position. In case limit cycling appears report the amplitude and cycle time.
	Stability
	Check the (steady-state) stability of the instrument at 10 %, 50 % and 90 % input. Report obvious instability and or limit cycling. In the last case also report the amplitude and cycle time. In case of instability or limit cycling perform the auto-tuning procedure and report the resulting changes of the relevant control parameters and possible improvement of stability.

6 Other considerations

6.1 Safety

Electrically powered positioners shall be examined to determine the degree to which their design protects against accidental electric shock in accordance with IEC 61010-1.

For application in hazardous locations a positioner shall be certified by an authorised body in accordance with the relevant parts of IEC 60079.

For application in safety shutdown systems the vendor shall provide safety parameters for the positioner according to IEC 61508 or IEC 61511.

6.2 Degree of protection provided by enclosures

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

6.3 Electromagnetic emission

If required, emission measurements shall be performed in accordance with CISPR 11.

6.4 Variants

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

7 Evaluation report

The evaluation report shall be prepared in accordance with IEC 61298-4.

The results of the design review shall be reported as described in 4.3.2.

The following supporting information should also be included in the evaluation report:

- Date, location of tests; names of persons conducting the tests and recording the data.
- Description of the positioner tested, including model number, serial number, whether it is single- or double-acting, and claimed static gain.

- Description of the actuator and valve used in the tests including model number; serial number; single- or double-acting; rated travel; actuator pressure range; nominal effective area; volume(s) at zero and 100 % travel (on both sides in the case of a double-acting actuator); spring rate; friction load; inertia load (all moving parts).
- Tests included and omitted. Any other conditions affecting the test results (e.g. deviations from recommended environmental conditions) should also be reported.
- Description of test set-up (including location of positioner feed connection), supply regulators, volume tanks and instrument tubing size and lengths.
- List of test equipment used.
- Output data: range, mean travel (percentage of span) and location of output transducer connection.
- Input data: range, amplitude (percentage of span) and location of input signal transducer connection.
- Supply pressure and medium.

The test laboratory shall store all the original documentation related to the measurements made during the tests for at least two years after the report is issued.

Annex A
(normative)

Vibration test set-up

Vibration tests of an intelligent positioner shall be performed on an assembly as shown below.

The actuator shall be provided with a packing box. The packing shall be lightly compressed so that the assembly shows stable control.

The rigidity of the vibration table and of the mounting means for the DUT shall be such that the vibration is transferred to the normal mounting point of the DUT with a minimum of loss or gain.

The control accelerometer measures and controls the vibration level of the vibration table. The response accelerometer is mounted on the positioner in the direction of vibration. It measures the possible amplification of the positioner due to the flexibility of the bracket with which the positioner is mounted on the valve/actuator assembly. Furthermore, the stem travel shall be measured with a vibration-resistant displacement sensor.

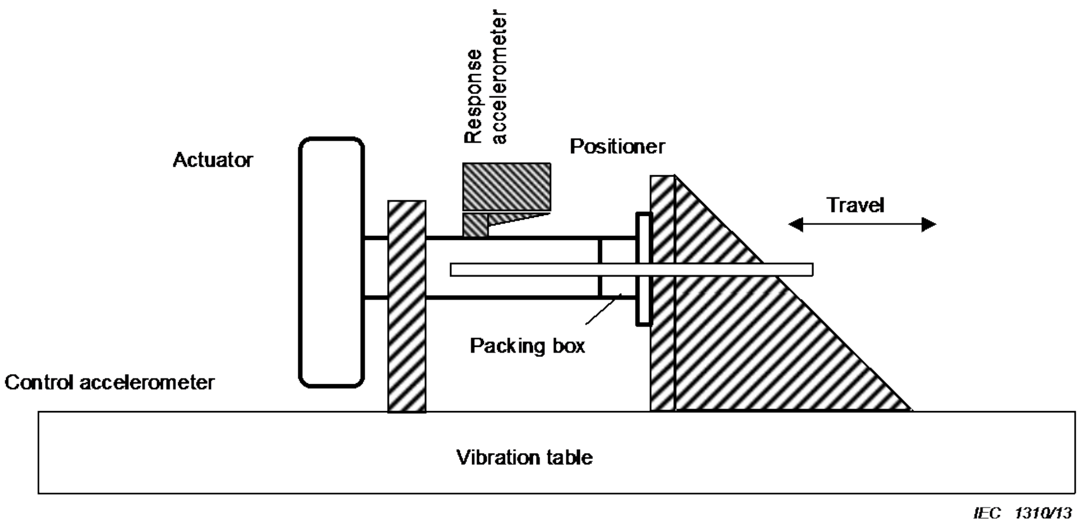

Figure A.1 – Test set-up for vibration test

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