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Industrial-process control valves –
Part 4: Inspection and routine testing

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Industrial-process control valves - Part 4: Inspection and routine testing

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS CONTROL VALVES –

Part 4: Inspection and routine testing

FOREWORD

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IEC 60534-4 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2006. This edition constitutes a technical revision.

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

a) remove details about hydrostatic test but state that to be performed according to valve design code;
b) include mandatory test for valve packing;
c) put in evidence limits of reduced differential pressure seat leakage test procedure;
d) introduce details about low temperature seat leakage test;
e) extend dimensional range for leakage class VI to less than 25 mm and over 400 mm seat diameter;

f) include stroking time tests.

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

Draft	Report on voting
65B/XX/FDIS	65B/XX/RVD

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

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

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

A list of all parts in the IEC 60534 series, published under the general title *Industrial-process control valves*, can be found on the IEC website.

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

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- withdrawn,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

INDUSTRIAL-PROCESS CONTROL VALVES –

Part 4: Inspection and routine testing

1 Scope

This part of IEC 60534 specifies the requirements for the inspection and routine testing of control valves manufactured in conformity with the other parts of IEC 60534.

This document is applicable to valves with pressure ratings not exceeding Class 2500. The requirements for actuators apply only to pneumatic actuators.

This document does not apply to the types of control valves where radioactive service, fire safety testing, or other hazardous service conditions are encountered. If a standard for hazardous service conflicts with the requirements of this document, the standard for hazardous service should take precedence.

NOTE This document can be extended to higher pressure ratings by agreement between the purchaser and the manufacturer.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60534 (all parts), *Industrial-process control valves*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the IEC 60534 series and the following apply.

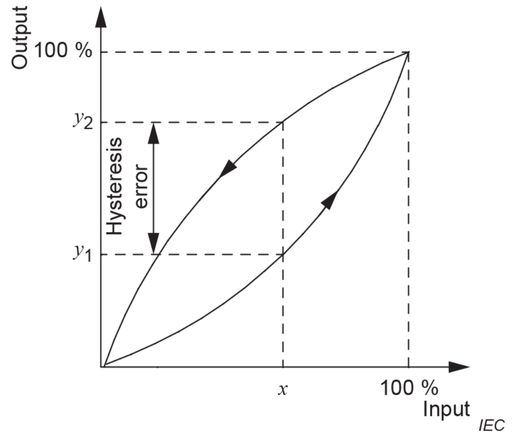
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

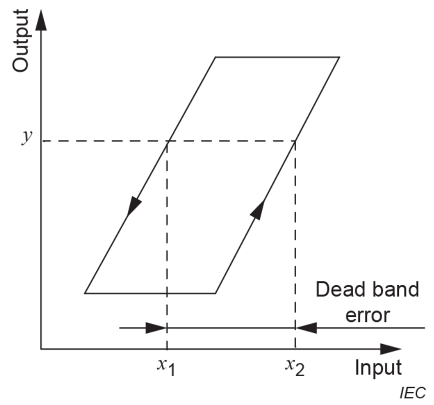
3.1
bench range
range of pressures to the actuator within which the nominal travel is performed in both directions, with no pressure in the valve, but including friction forces

Note 1 to entry: The actuator operating range, i.e. when the valve is installed under actual process conditions, will be different from the bench range.

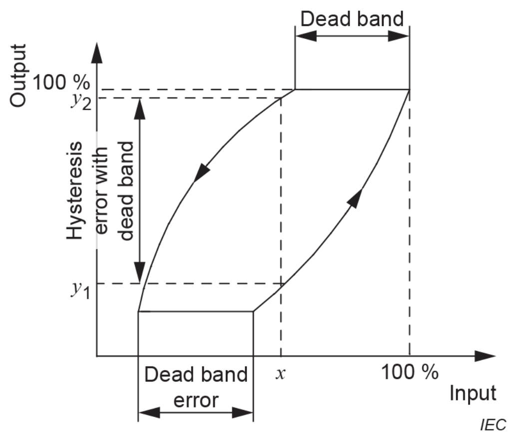
3.2
dead band
finite range of values within which reversal of the input variable does not produce any noticeable change in the output variable (see Figure 1)



a) Hysteresis



b) Dead band



c) Hysteresis with dead band

Figure 1 – Hysteresis and dead band

3.3
dead band error
maximum value of the span of the dead band (over the measuring range)

3.4
hysteresis
property of a device or instrument whereby it gives different output values in relation to its input values depending on the directional sequence in which the input values have been applied (see Figure 1)

3.5
hysteresis error
maximum deviation between the two calibration curves of the measured variable as obtained by an upscale going traverse and a downscale going traverse over the full range and subtracting the value of the dead band

3.6
type inspection and testing
inspection and testing carried out by the manufacturer in accordance with its own procedures to assess whether products made by the same manufacturing process meet the requirements of the purchase order

Note 1 to entry: The products inspected and tested need not necessarily be the products actually supplied.

3.7
actual inspection and testing
inspection and testing carried out, before delivery, according to the technical requirements of the purchase order, on the products to be supplied or on test units of which the product supplied is part, in order to verify whether these products comply with the requirements of the purchase order

4 Requirements

4.1 General

Each valve shall be submitted to the mandatory tests specified in Table 1. Supplementary tests given are subject to agreement between manufacturer and purchaser. An inspection and routine testing check list as specified by the present document is given in Annex B.

Table 1 – Tests

Test	Category	Reference
1. Shell hydrostatic test	M	4.2 and 5.4
2. Seat leakage test	M	4.3 and 5.5
3. Packing test	M [b]	4.4 and 5.6.2
	S [b]	4.4 and 5.6.3
4. Rated valve travel [a]	M	4.5 and 5.7
5. Dead band [a]	S	4.6 and 5.8
6. Flow capacity	S	4.7 and IEC 60534-2-3
7. Flow characteristic	S	4.7 and IEC 60534-2-4
8. Stroking time test	S	5.9

M = Mandatory
S = Supplementary

The shell hydrostatic test shall be performed first for safety reasons. Other tests should be done in the sequence given above.

[a] The results of tests of a valve under static conditions in a factory generally do not correspond to performance under working conditions. This document is intended only to provide guidance for negotiations between the manufacturer and the purchaser relative to tests of a specific valve.

[b] The packing test shall be performed during the shell hydrostatic test if packing is installed during that test in accordance with 4.4 and 5.6.2. The supplementary packing test can also be performed in accordance with 4.4 and 5.6.3 if desired or specified by the customer.

4.2 Hydrostatic test

All control valve assemblies, excluding welded on fittings, with or without the actuator fitted, shall be subject to a hydrostatic test as specified in 5.4.

4.3 Seat leakage test

The manufacturer shall advise if the achievable leak rate is less than the maximum allowed leak rate. If agreed to by the manufacturer and the user, the actual leak rate and allowed leak rate and the corresponding test pressure may be reported on the final certification.

Leakage shall be specified by the following code:

X	X	X
↓	↓	↓
Leakage class as shown in Table 3: I to VI	Test fluid G: air or nitrogen L: water	Test procedure 1 or 2

Example: III L 1

The seat leakage test as described in 5.5 shall be performed on each valve.

These seat leakage provisions do not apply to control valves with rated flow coefficients less than the following:

$$K_v = 0{,}086; \quad C_v = 0{,}1$$

Class VI is intended to apply to resilient seated valves only.

NOTE 1 This part of the standard cannot be used as a basis for predicting leakage when the control valve is installed under actual operating conditions.

NOTE 2 The actual and allowed leak rates, along with the corresponding test pressure, can also be included in the test certification upon agreement between the manufacturer and the buyer.

4.4 Packing test

This test, as described in 5.6, applies to the main valve packing. Secondary packing of the bellows may be excluded from this test when it is not under pressure during the hydrostatic test.

4.5 Rated valve travel test

Travel adjustment of control valves shall be verified by test in the factory as described in 5.7.

4.6 Dead band tests

The purpose of the dead band test is to measure the change in operating signal required to produce a reversal of stem (or shaft) movement at approximately 25 %, 50 % and 75 % of the rated travel of the valve actuator. This tests as described in 5.8 shall be performed on the assembly as it will be supplied.

4.7 Additional tests

Additional tests such as flow capacity, flow characteristic, stroking time, hysteresis, etc. (which are outside the scope of this standard), if required, shall be the subject of agreement between the manufacturer and the purchaser.

5 Tests procedures

5.1 Measuring instruments

5.1.1 General

Performance of measuring instruments is based on IEC 61298. The installation of all instruments shall be capable of meeting the requested accuracy.

5.1.2 Pressure measuring instruments

The analogue or digital pressure measuring instruments used in testing shall be of the indicating or recording type but shall be installed in such a manner that they represent the actual pressure in the component under test. The measuring equipment shall be capable of measuring the test pressure with a limit deviation of ±5 % of the required test pressure. For dead band testing, the inaccuracy of the instruments shall not exceed ±0,5 % of full range, and the maximum signal shall be not less than 50 % of the instrument range. The readout of attached digital positioners can be used for the pressure measurement if the stated accuracy is maintained.

5.1.3 Flow measuring instruments

The accuracy of the instruments used for measuring seat leakage shall be within ±10 % of full scale and shall be used within 20 % to 80 % of the scale range.

5.1.4 Travel measuring instruments

The accuracy of the instruments used to measure travel shall be within ±0,5 % of the rated travel. Digital positioners may be used for deadband measurements if the repeatability is ±0,5 % or better.

5.1.5 Calibration

It shall be the valve manufacturer's responsibility to maintain the accuracy of the measuring instruments. Calibration records shall be made available upon request.

5.2 Test medium

The test medium shall be liquid or gas, as specified in each test description.

a) Liquid: water at a temperature between 5 °C and 50 °C. The water may contain soluble oil or a corrosion inhibitor.
b) Gas: air or nitrogen in clean condition, at a temperature between 5 °C and 50 °C. Clean helium gas or nitrogen gas may also be used for low temperature seat leakage test using the pressure and temperature corrections given in Table 2, footnote c.

5.3 Test fixtures

Test fixtures shall not subject the valve to externally applied stresses that may affect the results of the tests.

NOTE The test equipment can apply external loads sufficient to react the forces resulting from the test pressure.

When using different test equipment and procedures to those detailed in this document, the manufacturer shall be able to demonstrate the equivalence of its test procedures and acceptance criteria with the requirements of this document.

For butt welding end valves when end plugs are used, the seal point shall be as close to the weld end as practical without over-stressing the weld preparation.

5.4 Hydrostatic test

A hydrostatic shell test shall be performed according to the valve design code (or standard) and/or to the applicable local regulations.

If a valve is dual pressure rated (inlet rating higher than outlet rating), it may be necessary to separate the high pressure portion of the valve from the low pressure portion with a temporary barrier, and test each portion with its respective test pressure.

Components such as bellows, diaphragms, backseats or stem packing which may be damaged by the hydrostatic test pressure may be temporarily removed. If packing is present during the hydro test, it shall be tested during the hydro test in accordance with the procedures given in 5.6.

Welded-on fittings (nipples, reducers and/or expanders) shall not be considered as part of the valve assembly and, therefore, need not be included in the hydrostatic test. If it is not practical to hydrostatically test the valve alone, the valve plus fitting assembly may be tested at the valve hydrostatic pressure provided the fittings are adequate to sustain the said pressure. If agreed upon between the manufacturer and the purchaser, the valve may be retested after the fittings are welded on at a pressure in accordance with the applicable piping specifications.

5.5 Seat leak test

5.5.1 Test medium

The test medium shall meet the requirements of 5.2.

5.5.2 Actuator adjustments

The actuator shall be adjusted to meet the operating conditions specified. The required closing thrust or torque, as obtained from air pressure, a spring or other means, shall then be applied. No allowance or adjustment shall be made to compensate for any difference in seat load obtained when the test differential is less than the maximum valve operating differential pressure.

On valve body assemblies made for stock, tested without the actuator, a test fixture shall be utilized which applies a net seat load not exceeding the manufacturer's normal expected load under maximum service conditions.

5.5.3 Test procedure

5.5.3.1 General

The test medium shall be applied to the normal or specified valve body inlet. The valve body outlet shall be open to atmosphere or connected to a low head-loss flow measuring device with its outlet open to the atmosphere. Provisions shall be made to avoid subjecting the measuring device to pressures above the safe operating pressure resulting from inadvertent opening of the valve under test.

When liquid is used, the valve shall be opened and the valve body assembly filled completely, including the outlet portion and any downstream connected piping. The valve shall then be closed. Air pockets shall be eliminated from the valve body and piping.

When the leakage flow rate has been stabilised, the rate of flow should be observed over the period of time that is necessary for obtaining the accuracy specified in 5.1.3.

The maximum allowable seat leakage as specified for each class shall not exceed the values in Table 3 using the test procedure as defined.

The seat leakage test, carried out with reduced differential pressure used as given in test procedure 1 (5.5.3.2), is used to verify the quality of the sealing surfaces and the alignment of internal parts, but it cannot be used to verify the mechanical strength and rigidity of parts required for sealing, nor can it be used to verify the correct sizing of the actuator for the maximum operating differential pressure since the seat load effect is disregarded.

For valves produced in a single copy, or when testing prototypes for a new series, it is therefore recommended to perform the seat leak test in a manner that tests the whole valve closure structure at the maximum operating differential pressure, using test procedure 2 (5.5.3.3), or to adjust the actuator thrust by agreement with the purchaser.

5.5.3.2 Test procedure 1

The pressure of the test medium shall be between 300 kPa and 400 kPa (3 bar and 4 bar) gauge or within ±5 % of the maximum operating differential pressure specified by the purchaser if it is below 350 kPa (3,5 bar). See Table 3 for guidance on what fluid should be used.

5.5.3.3 Test procedure 2

The test differential pressure shall be within ±5 % of the maximum operating differential pressure across the valve as specified by the purchaser.

5.5.4 Leakage specifications

Leakage classes, test mediums, test procedures and maximum seat leakages shall be specified to be in accordance with Table 3.

See Annex A for example calculations of rated valve capacity and allowable seat leakage.

Table 2 – Maximum seat leakage for each leakage class

Leakage class	Test medium	Test procedure	Maximum seat leakage
I	As agreed between the purchaser and the manufacturer		
II	L or G	1	5×10^{-3} × rated valve capacity [a]
III	L or G	1	10^{-3} × rated valve capacity [a]
IV	L	1 or 2	10^{-4} × rated valve capacity
	G	1	10^{-4} × rated valve capacity [a]
IV-S1	L	1 or 2	5×10^{-6} × rated capacity
	G	1	5×10^{-6} × rated capacity [a]
V	L	2	$1,8 \times 10^{-7} \times \Delta p$ [kPa] $\times D$ l/h ($1,8 \times 10^{-5} \times \Delta p$ [bar] $\times D$) [a]
	G	1	$10,8 \times 10^{-6} \times D$ Nm³/h [c] $11,1 \times 10^{-6} \times D$ std m³/h [c]
VI (see note 2)	G	1	$3 \times 10^{-3} \times \Delta p$ [kPa] × leakage rate factor [b] ($0,3 \times \Delta p$ [bar] × leakage rate factor) [b]

D is the seat diameter (mm); L = liquid; G = gas

[a] For the conversion of the compressible fluid volumetric flow rate, use standard conditions, which is an absolute pressure of 1 013,25 mbar and 15,6 °C, or normal conditions, which is an absolute pressure of 1 013,25 mbar and 0 °C.

[b] Leakage rate factors for Class VI:

Seat diameter	Allowable leakage rate factor	
mm	ml/min	Bubbles/min
≤ 25	0,15	1
40	0,30	2
50	0,45	3
65	0,60	4
80	0,90	6
100	1,70	11
150	4,00	27
200	6,75	45
250	11,1	–
300	16,0	–
350	21,6	–
≥ 400	0,071·Seat diameter	– [d]

The number of bubbles per minute as tabulated is a suggested alternative based on a suitable calibrated measuring device, in this case a 6 mm tube (outer diameter; wall thickness 1 mm) submerged in water to a depth of between 5 mm and 10 mm. The tube end should be cut square and smooth with no chamfers or burrs, and the tube axis should be perpendicular to the surface of the water.

If the valve seat diameter differs by more than 2 mm from one of the values listed, the leakage rate may be obtained by interpolation, assuming that the leakage rate varies as the square of the seat diameter.

[c] The maximum seat leakage in the table refers to air/nitrogen at the test procedure 1 conditions. If different test pressures are required, e.g. test procedure 2, subject to agreement between the user and manufacturer, then the maximum allowable leakage flow rate in Nm^3/h with air or nitrogen as the test medium shall be:

$10{,}8 \times 10^{-6} \times ((p_1 - 101)/350) \times (p_1/552 + 0{,}2) \times D$ where p_1 is the inlet pressure in kPa absolute.

Or, $10{,}8 \times 10^{-6}\ ((p_1 - 1{,}01)/3{,}5) \times (p_1/5{,}52 + 0{,}2) \times D$ when p_1 is in bar absolute

In the case of other gases, like Helium or Nitrogen, with different inlet pressure and inlet temperature, the maximum allowable leakage flow rate in Nm^3/h shall be:

$10{,}8 \times 10^{-6} \times ((p_1 - 101)/350) \times (p_1/552 + 0{,}2) \times D \times (288{,}15/T_1) \times (\eta_{Air}/\eta_{Gas})$

where p_1 is the inlet pressure in kPa absolute

Or, $10{,}8 \times 10^{-6}\ ((p_1 - 1{,}01)/3{,}5) \times (p_1/5{,}52 + 0{,}2) \times D \times (288{,}15/T_1) \times (\eta_{Air}/\eta_{Gas})$

where p_1 is in bar absolute in bar absolute,

T_1 the inlet temperature of the gas in K, η_{Air} the dynamic viscosity of air at 288.15 K and η_{Gas} the dynamic viscosity of the test gas at T_1.

These conversions assume laminar flow and are only valid with atmospheric outlet pressure. They shall not be used to predict flow rates under actual operating conditions.

[d] For seat diameters 400 mm and over the maximum seat leakage for leakage class VI is about 40 % of the maximum seat leakage for leakage class V, test procedure 1.

5.6 Packing test

5.6.1 General

This test can be performed at the same time as the hydrostatic test, per 5.6.2, or the seat leak test, as per 5.6.3. Procedure A, 5.6.2, is the procedure that shall be used unless otherwise specified by purchaser or manufacturer. If the control valve shall be subjected to production acceptance testing on fugitive emissions (such as ISO 15848-2), the packing test can be waived.

5.6.2 Procedure A

MANDATORY (Packing test performed during hydrostatic test)

5.6.2.1 Packing tightening

The packing shall be tightened to the recommended procedure from the manufacturer. Tightening of the packing shall not be modified after the packing test. Rated travel and dead band tests as per 4.5 and 4.6 shall be completed without modification to the packing tightness.

5.6.2.2 Test medium

The test medium shall be liquid, in accordance with 5.2 a).

5.6.2.3 Test pressure

The test pressure shall be set according to the valve design code. If there is any visible leakage during the test, the pressure may be reduced to 1,1 times the allowable operating pressure at room temperature, and leakage rechecked.

5.6.2.4 Test procedure

Follow the procedure of the selected valve design code; while pressurized, visually check for leakage through the packing.

5.6.2.5 Acceptance criteria

There can be no visible leakage through the packing.

5.6.3 Procedure B

SUPPLEMANTARY (Which can be done during seat leak test or by itself)

5.6.3.1 Packing tightening

The packing shall be tightened to the recommended procedure from the manufacturer. Tightening of the packing shall not be modified until rated travel and dead band tests as per 4.5 and 4.6 have been completed.

5.6.3.2 Test medium

The test medium shall be gas, in accordance with 5.2 b).

5.6.3.3 Test pressure

The gas pressure inside the valve shall be between 300 kPa and 400 kPa (3 bar and 4 bar) gauge or within ±5 % of the maximum operating pressure specified by the purchaser if it is below 350 kPa (3,5 bar) (or refer to 5.5.3.2). Test procedure:

- Pressurize the valve with the test medium.
- Stroke the valve through the complete valve travel at least two times.
- Check the packing tightness before, and after the stroking.

5.6.3.4 Acceptance criteria

No visible leakage shall occur at the packing, using leak detection fluid or immersing the valve in water.

5.7 Rated valve travel test

5.7.1 General

Rated valve travel tests are to be performed on the control valve (with its actuator) without internal pressure and with packing tightened to withstand 5.6.2.1.

5.7.2 Control valves with positioners

Control valves with positioners shall start to open (or close) when an input signal between 0 % and 3 % of span is added to the lower value of the signal range. They shall be fully open (or closed) when a signal between 97 % and 100 % of the signal range is applied.

For multirange applications, use 6 % instead of 3 %, and 94 % instead of 97 %.

NOTE For digital positioners, these values are optional because they can be programmed.

5.7.3 Control valves with spring-opposed actuators without positioners

a) Control valves which open with increasing signal shall reach 100 % of travel when the upper limit of the bench range is applied and shall be fully closed when the lower limit of the bench range is applied.

b) Control valves which close with increasing signal shall reach 100 % of travel when the lower limit of the bench range is applied and shall be fully closed when the upper limit of the bench range is applied.

Because of hysteresis, dead band and manufacturing tolerances (spring, diaphragm area, etc.), there can be a difference between the specified bench range and its in service values. Verification of the bench range is required to assure that the correct spring has been installed. The lower value of the bench range for a control valve, which opens with increasing actuator pressure, and the upper value of the bench range for a control valve, which opens with decreasing actuator pressure, affect the shutoff capability of the valve and should be checked.

5.7.4 Control valves with double-acting actuators without positioners

The test is carried out without a positioner. Control valves shall reach 100 % of travel when the specified air pressure is supplied to one of the two chambers and shall be fully closed when the specified air pressure is supplied to the other chamber. During the test, the non-pressurised chamber of the actuator shall be exhausted to the atmosphere.

5.8 Dead band tests

5.8.1 General

Dead band tests are to be performed on the control valve (with its actuator) without internal pressure and with packing tightened according to 5.6.2.1.

5.8.2 Test equipment

5.8.2.1 Test equipment for manually recorded test

The stem (or shaft) movement is detected by a dial indicator. Pneumatic signals are measured by a manometer (water or mercury) or a sensitive test type pressure gauge. Electrical signals are measured by a test meter of adequate range and sensitivity.

5.8.2.2 Test equipment for automatically recorded test

The stem (or shaft) movement and the operating signal are continually recorded by an analogue X-Y plotter capable of measuring the full range of the travel and the operating signal. This is used in conjunction with a displacement to voltage converter and a pressure or current to voltage converter. Valve diagnostic instruments, including digital valve positioners, that incorporate these features may also be used for this test.

5.8.3 Test procedure

5.8.3.1 Test procedure for valves with spring-opposed actuators

Starting with the valve actuator at one end of the travel (0 % or 100 %), the operating signal is varied until the stem (or shaft) has moved to 25 % of the rated travel. The signal is held at this point and its value (A) recorded. The signal is then slowly reversed until the stem (or shaft) starts to move in the reverse direction. The value (B) of the operating signal at the commencement of this reverse movement is recorded. Similar readings are taken and recorded at 50 % and 75 % of the rated travel.

The dead band x at each of the reference points is the change in operating signal applied to produce the reverse movement of the stem (or shaft). Dead band x is expressed as a percentage of the full span of the operating signal as given by the following equation:

$$x = \frac{|A - B|}{a - b} \times 100\ \%$$

where

x is the dead band;

A is the signal recorded at termination of travel;

B is the signal required to cause reverse movement;

a is the upper limit of signal range;

b is the lower limit of signal range.

The data required for dead band calculation may be obtained from a combined hysteresis and dead band test at the manufacturer's option if the testing and data recording meet the above requirements from the dead band portion of the testing. Refer to Figure 1c.

5.8.3.2 Test procedure for valves with double-acting actuators

For valves with double-acting actuators, the test procedure is the same as in 5.8.3.1, except that the signal is applied to the positioner. The actuator may be tested without the positioner subject to agreement between the manufacturer and the purchaser. In this case, the difference between the air pressure in the two chambers shall be recorded.

5.8.4 Acceptance criteria

See Table 3 for maximum recommended values for dead band error.

Table 3 – Maximum recommended values of dead band

Valve type	Recommended maximum values of dead band (% of full range input signal)
Valve with actuator, no positioner	6,0 [a]
Valve with positioner disengaged.	15,0 [b]
Valve with actuator, with positioner	1,0 [c]

[a] When dead band values exceed 6 %, valves should be equipped with a positioner.

[b] Values exceeding 15 % are permissible provided that supplementary tests (e.g. stroking time, dead time) or equivalent dynamic analyses are performed. Dynamic performance of the control valve can be affected by high friction.

[c] By agreement between the manufacturer and the purchaser, dead band tests for valves and actuators equipped with positioners may be replaced by certification of the static positioner performance

5.9 Stroking time test

5.9.1 General

Stroking time tests are to be performed on the control valve (with its actuator and accessories completely mounted and adjusted) without internal pressure and with packing tightened according to 5.6.2.1. The supply pressure shall be the minimum supply pressure as given in the valve specification. Special care shall be taken to avoid external influence on the stroking time, for example by not sufficient air supply capacity.

5.9.2 Test equipment

The stem (or shaft) movement and the operating signal are continually recorded by a digital recorder or an analogue 2-channel X-t plotter capable of measuring the full range of the travel and the operating signal. This is used in conjunction with a displacement to voltage converter and a pressure or current to voltage converter. Valve diagnostic instruments that incorporate these features may also be used for this test.

5.9.3 Test procedures

5.9.3.1 Test procedure for on/off operation via solenoid valve

Opening time: The valve shall be in the closed position when the solenoid valve is energized or de-energized, as per order specification. The stroking time is the time from energizing or de-energizing the solenoid valve until the valve reaches its rated travel.

Closing time: The valve shall be in the open position when the solenoid valve is energized or de-energized, as per order specification. The stroking time is the time from energizing or de-energizing the solenoid valve until the valve reaches its defined closed position (normally defined by the end of valve stem/shaft movement).

5.9.3.2 Test procedure for control operation via valve positioner

This test can be performed on 100 % signal change or any fraction of this. Starting from valve stability at the start input signal for the test, the stroking time is the time from applying the operating signal change until the valve reaches 95% of the stem/shaft movement between the start position and the final end position (the position where the valve reaches stability again).

Annex A
(informative)

Example calculations of seat leakage

A.1 General

A.1.1 Overview

This annex provides example calculations of seat leakage for all the leakage classes in Table 2. The equations are taken from IEC 60534-2-1.

A.1.2 Valve description

Globe valve

DN 100

PN 40

Seat diameter: D = 100 mm

Rated flow coefficient C: K_v = 160 m^3/h

Pressure differential ratio factor: x_T = 0,72

Liquid pressure recovery factor: F_L = 0,90

A.1.3 Test differential pressures

The following test differential pressures are used:

Test procedure 1: Δp = 300 kPa (selected by manufacturer)

Test procedure 2: Δp = 3 500 kPa (maximum operating differential pressure specified by purchaser)

A.1.4 Calculation of rated valve capacity

A.1.4.1 General

The calculations of the rated valve capacities are made using the equations from IEC 60534-2-1.

A.1.4.2 Test procedure 1 using water as test medium

$$Q = N_1 \times F_p \times F_R \times C \sqrt{\frac{\Delta p}{\rho / \rho_o}} = 277 \text{ m}^3/\text{h}$$

(rated valve capacity)

where

N_1 = 0,1

F_p = 1

F_R = 1

C = K_v = 160 m^3/h

ρ/ρ_o = 1

Δp = 300 kPa

A.1.4.3 Test procedure 2 using water as test medium

$$p_1 = p_2 + \Delta p = 3\ 600 \text{ kPa}$$

where

$p_2 \approx 100$ kPa (open to atmosphere)

$\Delta p = 3\ 500$ kPa

$$\Delta_{pmax} = F_L^2\ (p_1 - F_F \cdot p_v) = 2\ 914 \text{ kPa}$$

(maximum allowable differential pressure for sizing purposes)

where

F_L = 0,90

p_1 = 3 600 kPa

F_F = 0,96

p_v = 2,34 kPa

Since $\Delta p_{max} < \Delta p$, the flow is therefore choked.

$$Q = N_1 \cdot F_L \cdot F_R \cdot C \sqrt{\frac{p_1 - F_F \cdot p_v}{\rho / \rho_o}} = 864 \text{ m}^3\text{/h}$$

(rated valve capacity)

where

N_1 = 0,1

F_L = 0,90

F_R = 1

C = K_v = 160 m^3/h

p_1 = 3 600 kPa

F_F = 0,96

p_v = 2,34 kPa

A.1.4.4 Test procedure 1 using air as test medium

$$p_1 = p_2 + \Delta p = 400 \text{ kPa (absolute)}$$

where

$p_2 \approx 100$ kPa (open to atmosphere)

Δp = 300 kPa

$$x = \frac{\Delta p}{p_1} = 0{,}75$$

where

Δp = 300 kPa

p_1 = 400 kPa

$$F_\gamma \cdot x_T = 0{,}72$$

where

F_γ = 1

x_T = 0,72

Since x shall not exceed $F_\gamma \cdot x_T$, then use x = 0,72 to calculate Y.

$$Y = 1 - \frac{x}{3 \cdot F_\gamma \cdot x_T} = 0{,}667$$

where

x = 0,72 (it must not exceed $F_\gamma \cdot x_T$)

F_γ = 1

x_T = 0,72

$$W = N_8 \cdot F_p \cdot C \cdot p_1 \cdot Y \sqrt{\frac{x \cdot M}{T_1 \cdot Z}} = 12\,529 \text{ kg/h}$$

(rated mass valve capacity)

where

N_8 = 1,1

F_p = 1

C = K_v = 160 m^3/h

p_1 = 400 kPa

Y = 0,667

x = 0,72

M = 28,97 kg/kmol

T_1 = 293 K

Z = 1

$$Q = N_9 \cdot F_p \cdot C \cdot p_1 \cdot Y \sqrt{\frac{x}{M \cdot T_1 \cdot Z}} = 9\,672 \text{ m}^3\text{/h}$$

(rated volumetric valve capacity)

where

N_9 = 24,6 (for normal conditions of p_s = 1 013,25 mbar and t_s = 273 K)

F_p = 1

C = K_v = 160 m^3/h

p_1 = 400 kPa

Y = 0,667

x = 0,72

M = 28,97 kg/kmol

T_1 = 293 K

Z = 1

A.1.5 Calculated maximum allowable seat leakages

Table A.1 shows the maximum allowable seat leakages for all of the leakage classes for the valve described in Clause A.1.2.

Table A.1 – Maximum seat leakage for each leakage class

Leakage class	Test medium	Test procedure	Maximum seat leakage
I	As agreed between purchaser and manufacturer		
II	Water	1	1,39 m³/h = 23,1 l/min
	Air	1	62,6 kg/h 48,4 m³/h = 806 l/min
III	Water	1	0,277 m³/h = 4,62 l/min
	Air	1	12,5 kg/h 9,67 m³/h = 161,2 l/min
IV	Water	1	0,027 77 m³/h = 0,462 l/min
		2	0,086 4 m³/h = 1,44 l/min
	Air	1	1,253 kg/h 0,967 m³/h = 16,1 l/min
IV-S1	Water	1	0,001 39 m³/h = 0,023 l/min
		2	0,004 32 m³/h = 0,072 l/min
	Air	1	0,062 6 kg/h 0,048 4 m³/h = 0,806 l/min
V	Water	2	0,063 l/h = 1,05 × 10^{-3} l/min
	Air	1	0,001 1 m³/hr = 0,0185 l/mn
VI	Air	1	1,53 ml/min = 1,53 × 10^{-3} l/min
NOTE All values of volumetric flow rate are for normal conditions which are an absolute pressure of 1 013,25 mbar and a temperature of 273 K.			

A.2 General

A.2.1 Overview

Clause A.2 provides example calculations of seat leakage for class VI and seat diameter over 400 mm.

A.2.2 Valve description

Butterfly valve:

DN 800

Seat diameter: D = 800 mm

A.2.3 Test differential pressure

The following test differential pressure is used:

Test procedure 1: Δp = 350 kPa.

Test medium = Air

A.2.4 Calculation of class VI maximum allowable seat leakage

Maximum allowable seat leakage for leakage class VI:

$$\mathit{Max\ leakage} = 3 \cdot 10^{-3} \cdot \Delta p \cdot \mathit{leakage\ rate\ factor}$$

where:

Δp is expressed in [kPa];

Leakage rate factor (from Table 3) is: (0,071 · Seat diameter) = 0,071 · 800 = 56,8 [ml/min];

Maximum allowed leakage with air:

$$\mathit{Max\ leakage} = 3 \cdot 10-3 \cdot 350 \cdot 56{,}8 = 59{,}64 \text{ [ml/min]} = 0{,}06 \text{ [l/min]}$$

NOTE All values of volumetric flow rate are for normal conditions which are an absolute pressure of 1 013,25 mbar and a temperature of 273 K.

Annex B
(informative)

Inspection and routine testing checklist (per IEC 60534-4)

Manufacturer:		Manufacturer reference no.:	
Customer:		Purchase order no.:	
Date:		Place of inspection:	
Visual inspection:			
Valve body	❑ OK	Bolts/nuts	❑ OK
Actuator	❑ OK	Accessories	❑ OK
Tubing	❑ OK	Marking	❑ OK
Tag no.	❑ OK		
Dimensional check:			
Face-to-face	❑ OK	Body connections	❑ OK
Electrical connections	❑ OK	Pneumatic connections	❑ OK
Outline dimensions	❑ OK		
Hydrostatic test:			
Body shell test	❑ OK	Packing test	❑ OK
Seat leakage test:			
Leakage class:		Test medium:	Test procedure:
Measured seat leakage:			❑ OK
Rated valve travel test	❑ OK	Dead band	❑ OK
Additional tests (only if agreed between manufacturer and purchaser):			
Flow capacity	❑ OK	Flow characteristics	❑ OK
Hysteresis	❑ OK	Stroking time	❑ OK
Documentation:			
Certificate of compliance	❑		
Test certificate	❑ Type		
Inspection certificate	❑ Type		

Signature Manufacturer

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Signature Customer/Inspector

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Bibliography

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

ISO 15848-2, *Industrial valves – Measurement, test and qualification procedures for fugitive emissions – Part 2: Production acceptance test of valves*

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