

Industrial-process control valves —

Part 9: Test procedure for response measurements from step inputs

ICS 23.060.40; 25.040.40

National foreword

This British Standard is the UK implementation of EN 60534-9:2007. It is identical with IEC 60534-9:2007, incorporating corrigendum June 2008.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum June 2008 is indicated in the text by AC1 AC1.

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

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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**Industrial-process control valves -
Part 9: Test procedure for response measurements from step inputs
(IEC 60534-9:2007)**

Vannes de régulation
des processus industriels -
Partie 9: Procédure d'essai
pour la mesure de la réponse
des vannes de régulation
à des signaux d'entrée échelonnés
(CEI 60534-9:2007)

Stellventile für die Prozessregelung -
Teil 9: Prüfverfahren zur Bestimmung
des Verhaltens von Stellventilen
bei Sprungfunktionen
(IEC 60534-9:2007)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 65B/632/FDIS, future edition 1 of IEC 60534-9, 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 was approved by CENELEC as EN 60534-9 on 2007-10-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2008-07-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2010-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60534-9:2007 was approved by CENELEC as a European Standard without any modification.

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INDUSTRIAL-PROCESS CONTROL VALVES –

Part 9: Test procedure for response measurements from step inputs

1 Scope and object

This part of IEC 60534 defines the testing and reporting of the step response of control valves that are used in throttling closed-loop control applications. A control valve consists of the complete, ready-to-use assembly of the control valve body, the actuator, and any required accessories. The most probable accessory is a valve positioner.

NOTE For background, refer to technical report ANSI/ISA-TR75.25.02 [6]¹.

The object of this standard is to define how to test, measure, and report control valve response characteristics in an open-loop environment. This information can be used for process control applications to determine how well and how fast the control valve responds to the control valve input signal.

This standard does not define the acceptable control valve performance for process control nor does it restrict the selection of control valves for any application. If this standard is used for evaluation or acceptance testing, the parties may agree to documented variations from these requirements.

The information using the defined test methods is specifically applicable to closed-loop feedback control but may have some application to open-loop control applications. It does not address valves used in on-off control service.

Tests specified in this standard may not be sufficient to measure the performance required for all applications. Not all control valve applications will require this testing.

2 Normative references

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

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

IEC 60534-4, *Industrial-process control valves – Part 4: Inspection and routine testing*

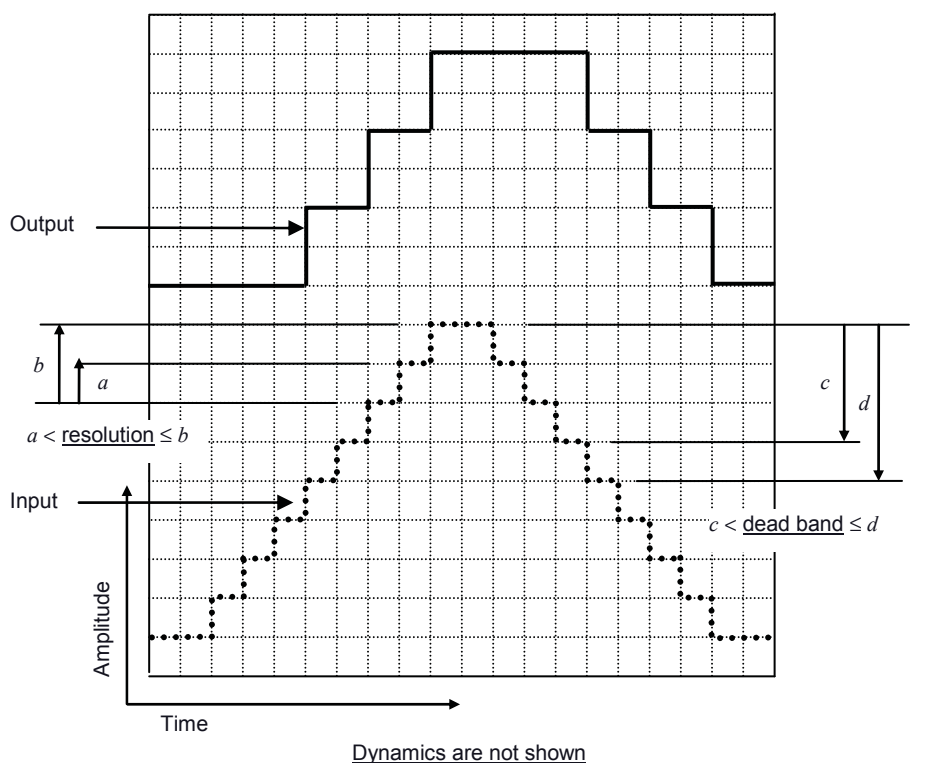
3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60534-1 and other parts of IEC 60534, apply.

NOTE 1 In the specific area of non-linear dynamics, it was determined that some terms defined in IEC 60050-351 or in [5] lacked the precision desired for these documents. Others were inconsistent with the terminology used in the non-linear control literature.

¹ Figures in square brackets refer to the Bibliography.

NOTE 2 Reference [6] explains applicable terms and explores control valve static and dynamic response characteristics important for process control. That information will aid correct interpretation and application of the test results obtained from the tests defined in this standard.



IEC 1630/07

Figure 1 – Dead band and resolution

3.1

closed-loop time constant

time constant of the closed-loop response of a control loop, used in tuning methods such as Internal Model Control (IMC) and Lambda Tuning and is a measure of the performance of a control loop

3.2

dead band

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

[IEC 60534-4, 3.2]

3.3

dead time

time interval between the instant when a variation of an input variable is produced and the instant when the consequent variation of the output variable starts

3.4

dynamic response

time-dependent output signal change resulting from a defined time-dependent input signal change

NOTE Commonly used input signal changes include impulse, pulse, step, ramp, and sinusoid [4]. Dynamic means that the control valve is moving. Dynamic response can be measured without process loading in bench-top tests, with simulated or active loading in a flow laboratory or under normal process operating conditions.

3.5**gain ratio** G_R

response gain G_Z divided by the response gain G_{Z02} determined from the multi-step test performed with a step size of 2 %. The ideal gain ratio equals 1,0 for tests about any nominal position

$$G_R = G_Z/G_{Z02}$$

NOTE Measuring the gain ratio may not be possible if a digital positioner with pulse-modulated output is involved in the system since, on such positioners, the gain measurement may give infinite values.

3.6**input step size** Δs

difference between the beginning and ending signal in a step change expressed as a per cent of the signal span

3.7**limit cycle**

oscillation caused by the non-linear behaviour of a feedback system

NOTE 1 These oscillations are of fixed amplitude and frequency and can be sustained in a feedback loop even if the system input change is zero. In linear systems, an unstable oscillation grows theoretically to infinite amplitude, but non-linear effects limit this growth [3].

NOTE 2 The occurrence of the limit cycle may be dependent on current valve position.

3.8**non-linear system**

system whose response depends on the amplitude and the nature of the input signal, as well as the initial conditions of the system. As an example, a non-linear system can change from being stable to unstable by changing the size of the input signal

NOTE When a non-linear system is driven towards a set point by feedback control action, it is likely to develop a limit cycle. The amplitude and frequency of such limit cycles are a function of the nature of the non-linearities which are present, and the effective gain of the feedback control action. As the gain of the feedback is increased, the frequency of the limit cycle is likely to increase. More aggressive gain increases may produce behaviour such as bifurcation, frequency doubling and eventually chaotic behaviour.

3.9**overshoot**

for a step response, the maximum transient deviation from the final steady-state value of the output variable, expressed as a percentage of the difference between the final and the initial steady-state values

3.10**relative travel** h

ratio of the travel at a given opening to the rated travel

[IEC 60534-1, 4.5.4]

3.11**resolution**

smallest step increment of input signal in one direction for which movement of the output is observed, expressed as a percentage of the input span

NOTE The term “valve resolution” in this standard means the tendency of a control valve to move in finite steps in responding to step changes in the input signal applied in the same direction. This happens when the control valve sticks in place, having stopped moving after the previous step change.

3.12

step response

time history of a variable after a step change in the input. In this standard, the step response can be stem position, flow, or another process variable

3.13

response flow coefficient

C_R

apparent flow coefficient as determined by testing in an operating type environment. The data available in the operating environment may differ from the laboratory data required by valve sizing standards

NOTE 1 Flow coefficients in current use are K_V and C_V depending upon the system of units. For further information, refer to IEC 60534-1.

NOTE 2 It will be noted that the dimensions and units on each of the following defined flow coefficients are different. However, it is possible to relate these flow coefficients numerically. This relationship is as follows:

$$\frac{K_V}{C_V} = 0,865$$

3.14

response gain

G_Z

ratio of the steady-state magnitude of the process change, ΔZ , divided by the signal step, Δs , that caused the change. One special reference response gain is defined as that calculated from the 2 % step size response time test which is designated as G_{Z02}

$$G_Z = \Delta Z / \Delta s$$

$$G_{Z02} = \Delta Z_{02} / \Delta s_{02}$$

3.15

sampling interval

Δt_s

time increment between sampled data points which is the inverse of the sampling rate, f_0

$$\Delta t_s = 1/f_0$$

NOTE As used in this standard, since more than one variable is being sampled, it is the time between the sets of sampled data. Ideally, all variables in one set are sampled at the same time. If data is recorded using analogue equipment, the time constant for the recording equipment should be less than, or equal to, the maximum allowed Δt_s .

3.16

sampling rate

f_0

rate at which data samples are taken or the number of samples per unit time (see 3.15)

3.17

sliding friction

F_R or T_R

force or torque required to maintain motion in either direction at a prescribed input signal ramp rate