
**Pneumatic fluid power — Electro-
pneumatic pressure control valves —**

**Part 1:
Main characteristics to include in the
supplier's literature**

*Transmissions pneumatiques — Appareils électropneumatiques de
distribution à commande continue de pression —*

*Partie 1: Principales caractéristiques à inclure dans la documentation
des fournisseurs*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 5, *Control products and components*.

This second edition cancels and replaces the first edition (ISO 10094-1:2010) which has been technically revised.

The main changes are as follows:

- Updates to the Scope: "proportional pressure control valves" changed to "proportional pressure control valves without electronic pressure feedback" and "pressure servo-valves (closed loop)" changed to "proportional pressure control valves with electronic pressure feedback";
- Revision of [Figure 1](#);
- Addition of two static characteristics, Sensitivity ([5.3.1.7](#)) and Offset ([5.3.1.8](#));
- The frequency responses ([5.4.4](#)) are now optional.

A list of all parts in the ISO 10094 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In pneumatic fluid power systems, power is transmitted and controlled through a gas under pressure within a circuit.

When pressure tracking or pressure regulation is required, electro-pneumatic continuous pressure control valves can be used to track a variable set point with low tracking error or to maintain the pressure of the gas at an approximately constant level.

These control valves continuously modulate the pneumatic pressure of a system in response to a continuous electrical input signal and link the electrical input value to a proportional pressure value.

It is therefore necessary to know some performance characteristics of these electro-pneumatic continuous pressure control valves in order to determine their suitability.

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Pneumatic fluid power — Electro-pneumatic pressure control valves —

Part 1:

Main characteristics to include in the supplier's literature

1 Scope

This document specifies which characteristics of electro-pneumatic continuous pressure control valves are to be included in the supplier's literature.

In accordance with ISO 5598, these control valves include:

- electrically modulated pneumatic proportional pressure valves,
- proportional pressure control valves without electronic pressure feedback, and
- proportional pressure control valves with electronic pressure feedback.

This document is limited to the characterization of components with an exhaust port to the atmosphere.

NOTE 1 The characteristics of non-electrically modulated pneumatic pressure control valves are specified in ISO 6953-1.

NOTE 2 The characteristics of electro-pneumatic continuous flow control valves are specified in ISO 10041-1.

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.

ISO 5598, *Fluid power systems and components — Vocabulary*

ISO 6953-1, *Pneumatic fluid power — Compressed air pressure regulators and filter-regulators — Part 1: Main characteristics to be included in literature from suppliers and product-marking requirements*

ISO 10094-2:2021, *Pneumatic fluid power — Electro-pneumatic pressure control valves — Part 2: Test methods to determine main characteristics to include in the supplier's literature*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598, ISO 6853-1, ISO 10094-2 and the following apply.

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

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

3.1 characteristic line

straight line drawn to represent the actual performance of a proportional pressure regulator passing by the mean regulated pressure readings of 5 % and 95 % of the full-scale

3.2 electro-pneumatic continuous pressure control valve

control valve which continuously modulates the pneumatic power of a system in response to a continuous electrical input signal and which links the electrical input quantity to a pressure value

3.3 inlet pressure

pressure at the inlet port of a component, piping or system

[SOURCE: ISO 5598:2020, 3.2.397]

3.4 electrical control signal set signal

electrical signal applied to a control device

3.5 control signal/pressure characteristic curve

graphical representation of the relationship between the regulated pressure and the electrical control signal on its full scale while the forward flow rate or the relief flow rate is null, at constant inlet pressure

3.6 minimum regulated pressure

pressure at the first point of the control signal/pressure characteristic curve

3.7 flow/pressure characteristic curve

graphical representation of the relationship between the regulated pressure and the forward flow rate or the relief flow rate while the control signal and the inlet pressure are maintained constant

3.8 pressure regulation characteristic

variation of the regulated pressure for a given control signal, under the effect of an inlet pressure variation, measured for a defined flow

3.9 maximum deviation

deviation from the characteristic line to the total of the maximum excursions of the regulated pressure p_2 above and below the characteristic line

4 Symbols

For the purposes of this document, the symbols and units listed in [Table 1](#) apply.

Table 1 — Symbols and units

Description	Symbol	Units
Maximum sonic conductance at the inlet	$C_{f,max}$	$m^3(s \cdot Pa)$ (ANR) ^b
Sonic conductance at the exhaust	C_r	$m^3(s \cdot Pa)$ (ANR) ^b
^a As described in ISO 11727.		
^b The reference atmosphere is defined in ISO 8778, i.e.: $T_0 = 293,15$ K, $p_0 = 100$ kPa (1 bar) and a relative humidity of 65 %.		

Table 1 (continued)

Description	Symbol	Units
Hysteresis	H	% FS
Linearity	L	% FS
Sensitivity	m	Pa/V, Pa/mA or Pa/numerical signal
Offset	O	%
Total relative pressure at the inlet port ^a	p_1	Pa
Total relative pressure at the outlet port ^a	p_2	Pa
Repeatability	r	% FS
Resolution	S	% FS
Maximal difference of the linearity	$\Delta p_{2,L,max}$	Pa
^a As described in ISO 11727.		
^b The reference atmosphere is defined in ISO 8778, i.e.: $T_0 = 293,15 \text{ K}$, $p_0 = 100 \text{ kPa}$ (1 bar) and a relative humidity of 65 %.		

5 Characteristics

5.1 General

Descriptive literature covering electro-pneumatic continuous pressure control valves shall include the characteristics given in 5.2 to 5.4.

The data provided by the supplier shall assist the user in selecting the best-suited electro-pneumatic continuous pressure control valve for the particular application.

5.2 Electric characteristics

The required minimum voltage, the required minimum current and the required minimum power of the power supply shall be given.

5.3 Static characteristics

5.3.1 Control signal/pressure characteristics at null forward flow rate or relief flow rate

5.3.1.1 Characteristic curve

The regulated pressure, p_2 , at null forward or relief flow rate shall be indicated on a graph as shown in Figure 1.

This characteristic straight line shall be plotted in accordance with ISO 10094-2, for a given inlet pressure, p_1 , indicated as a relative value as shown in Figure 1.

The test shall be performed in accordance with ISO 10094-2:2021, 7.2.1.

The offset value and the sensitivity of the characteristic straight line shall be indicated on the graph as shown in Figure 1.

5.3.1.2 Linearity

The linearity, L , expressed as a percentage of the regulated pressure full-scale, shall be calculated in accordance with ISO 10094-2:2021, Formula (1).

The obtained value gives the maximum difference between the regulated pressure mean values and the characteristic straight line shown in [Figure 1](#).

5.3.1.3 Control signal/pressure hysteresis

The hysteresis, H , expressed as a percentage of the regulated pressure full-scale, shall be calculated in accordance with ISO 10094-2:2021, Formula (2).

The obtained value gives the maximum difference between the regulated pressure values measured with both an increasing and decreasing control signal.

The hysteresis can also be expressed as an absolute value.

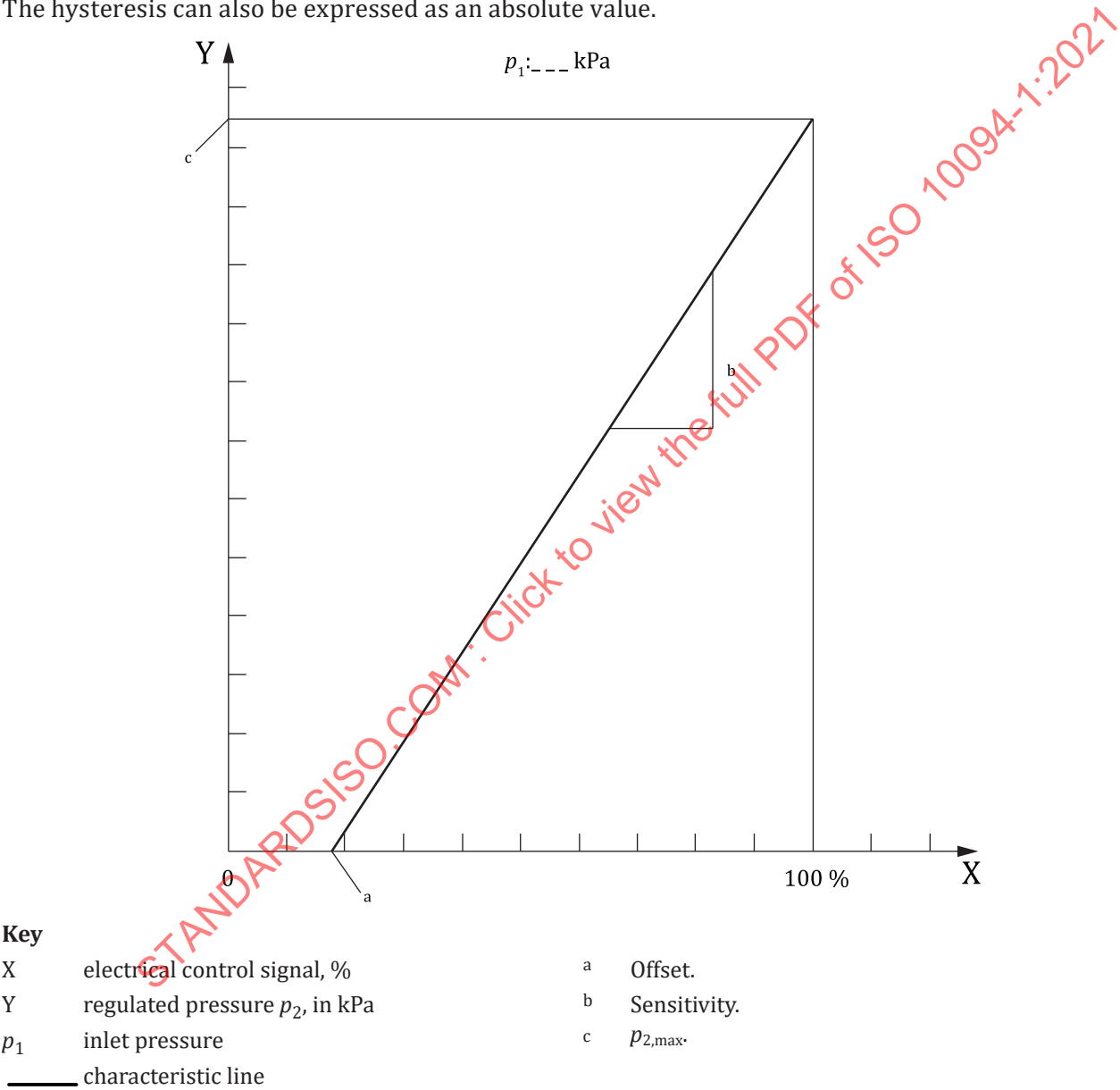


Figure 1 — Control signal/pressure characteristic curve at null forward flow rate or relief flow rate

5.3.1.4 Minimum regulated pressure

The test shall be performed in accordance with ISO 10094-2:2021, 7.2.2.

The minimum regulated pressure corresponds to the pressure at the first point which is within the allowable limits of linearity of the control signal/pressure characteristic curve determined in 5.3.1.2, as shown in Figure 2.

The minimum regulated pressure, expressed as a percentage of the regulated pressure full-scale, shall be determined in accordance with ISO 10094-2:2021, 7.3.4.

The measured points corresponding to the test of ISO 10094-2:2021, 7.2.2, the minimum regulated pressure, as well as the offset, shall be indicated on a graph as shown in Figure 2.

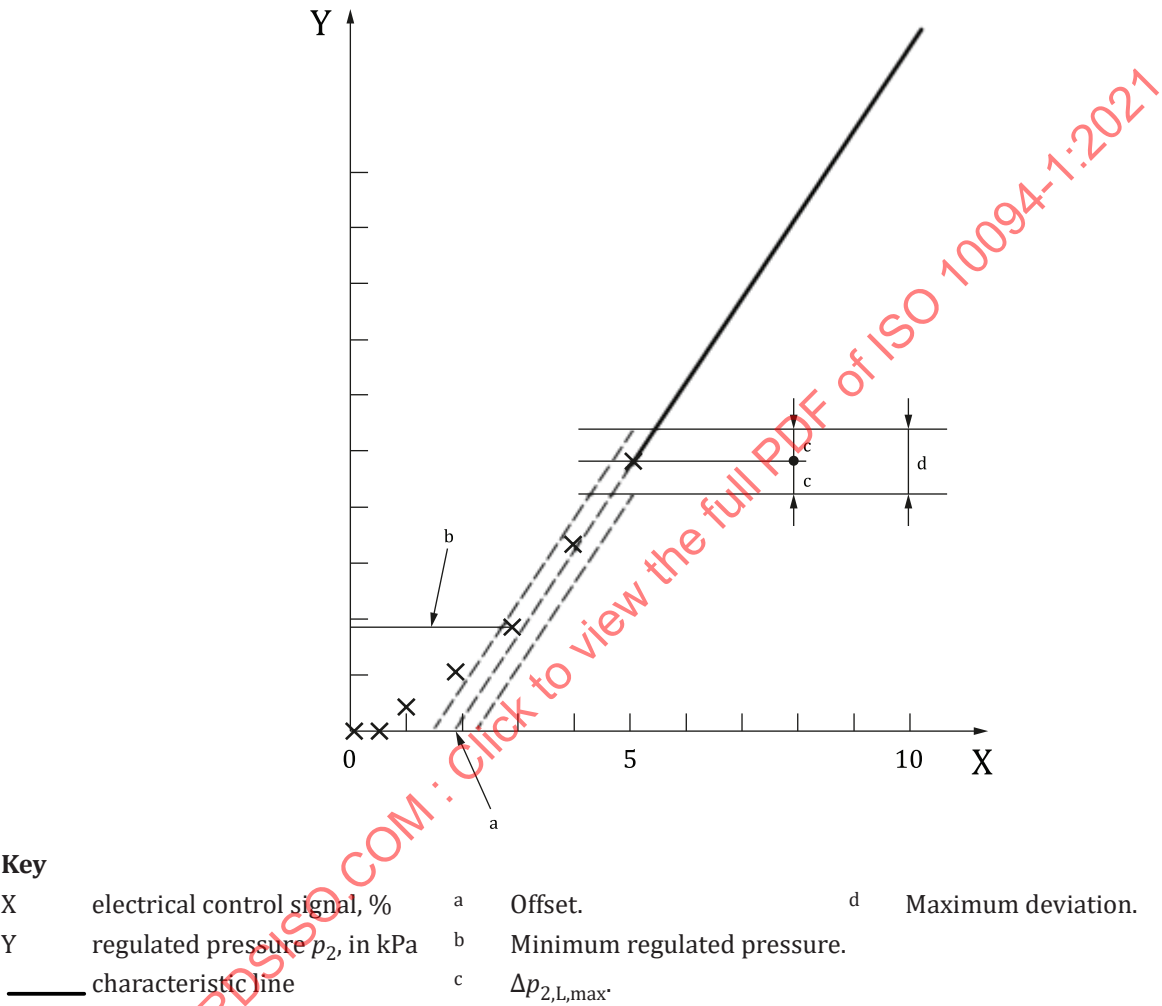


Figure 2 — Definition of the minimum regulated pressure and of the offset on the control signal/pressure characteristic curve at null flow rate

5.3.1.5 Resolution

The resolution, S , corresponds to the minimal difference between two control signal values for which there is a difference in the corresponding regulated pressure values.

The test shall be performed in accordance with ISO 10094-2:2021, 7.2.3.

The resolution, S , expressed in percentage of the control signal full-scale, shall be determined in accordance with ISO 10094-2:2021, 7.3.5.

5.3.1.6 Repeatability

The repeatability, r , corresponds to the maximal dispersion in regulated pressure, for a given electrical control signal.

The test shall be performed in accordance with ISO 10094-2:2021, 7.2.4.

The repeatability, r , expressed as a percentage of the regulated pressure full-scale, shall be determined in accordance with ISO 10094-2:2021, 7.3.6.

5.3.1.7 Sensitivity

The sensitivity, m , expressed as Pa/V, Pa/mA or Pa/numerical signal, corresponds to the characteristic ratio between the variation of the output signal and the variation of the control signal for arbitrarily variations.

The sensitivity, m , shall be calculated in accordance with ISO 10094-2:2021, Formula (5).

5.3.1.8 Offset

The offset, O , expressed as a percentage of the control signal full-scale, is the intersection of the characteristic straight line with the abscissa axis.

The test shall be performed in accordance with ISO 10094-2:2021, 7.2.1.

The offset, O , shall be calculated in accordance with ISO 10094-2:2021, Formula (6).

5.3.2 Flow/pressure characteristics

5.3.2.1 Characteristic curves

The regulated pressure shall be indicated by curves according to the graph shown in [Figure 3](#). Each curve describes the regulated pressure versus the forward flow rate and the relief flow rate for a given inlet pressure indicated as a relative value as shown in [Figure 3](#).

This graph shall have five curves differing by the settings of the electrical control signal. These settings and the test procedure shall be performed in accordance with ISO 10094-2:2021, 8.3.

Each curve shown in [Figure 3](#) is plotted in accordance with ISO 10094-2:2021, 8.4.1, taking, for each value of flow rate, the median value of two pressures measured with respectively increasing and decreasing flow rates.

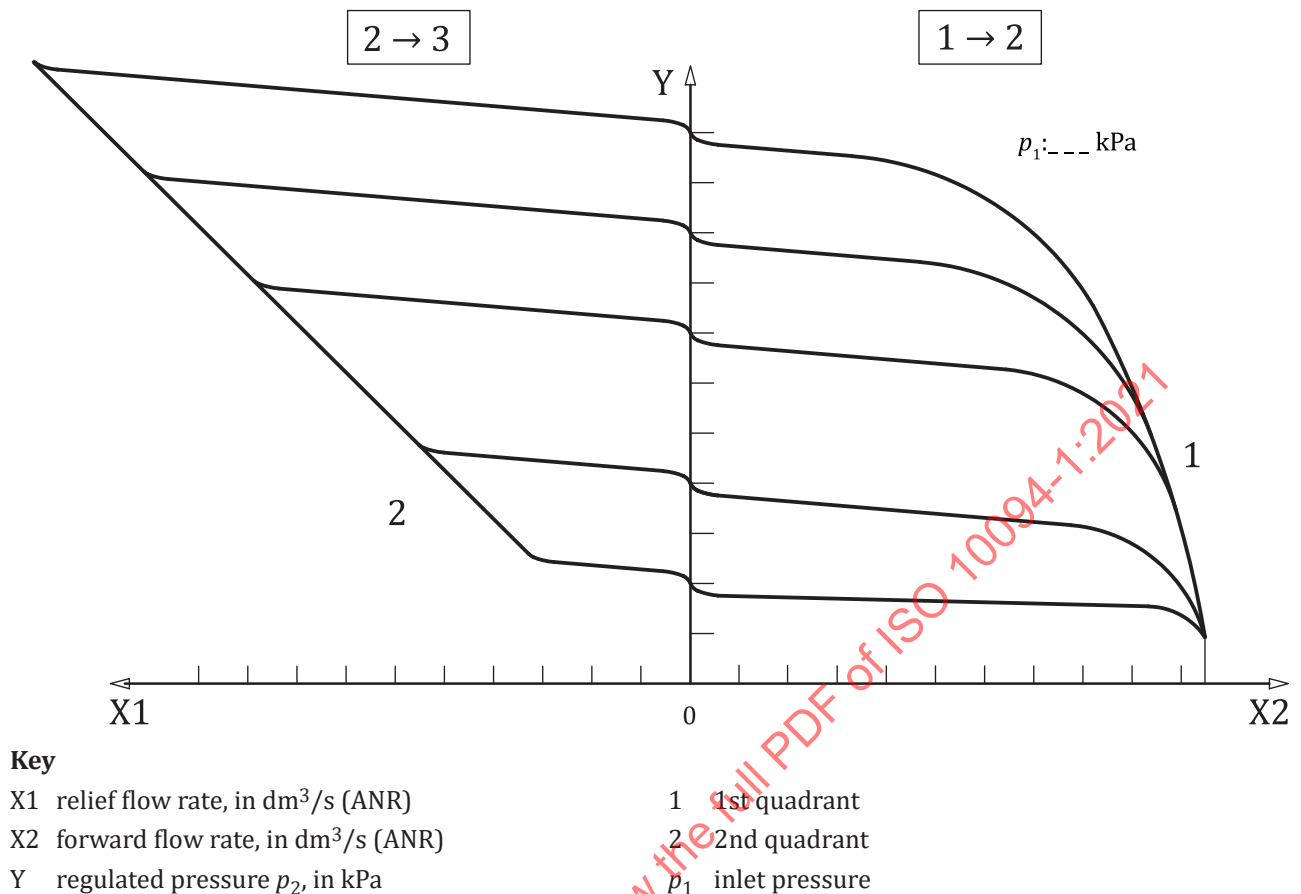


Figure 3 — Flow/pressure characteristic curves

5.3.2.2 Flow/pressure hysteresis

The hysteresis, H , expressed as a percentage of the regulated pressure full-scale, shall be calculated in accordance with ISO 10094-2:2021, 8.4.2.

The obtained value gives the maximum difference between the regulated pressure values measured with respectively increasing and decreasing flow rate.

5.3.2.3 Maximum forward sonic conductance

The maximum forward sonic conductance, $C_{f,max}$, is calculated in accordance with ISO 10094-2:2021, 8.4.3.

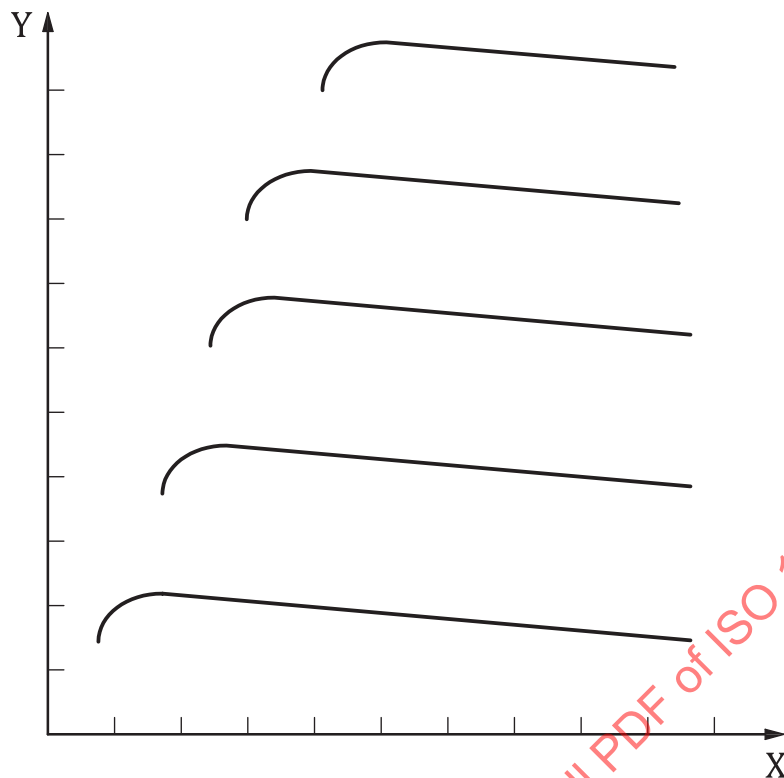
5.3.2.4 Maximum relief sonic conductance

The maximum relief sonic conductance, C_r , is calculated in accordance with ISO 10094-2:2021, 8.4.4.

5.3.3 Pressure regulation characteristics

The effects of the inlet pressure, p_1 , on the regulated pressure, p_2 , shall be indicated by curves on a graph as shown in [Figure 4](#). Each curve describes the variation of the regulated pressure versus the inlet pressure for a nearly steady flow rate.

The test shall be performed in accordance with ISO 10094-2:2021, Clause 9, and shall be performed for the same control signal settings as those used in [5.3.2.1](#).

**Key**X inlet pressure p_1 , in kPaY regulated pressure p_2 , in kPa**Figure 4 — Pressure regulation characteristic curves****5.3.4 Maximum leakage flow rate at null forward flow rate or relief flow rate**

The maximum leakage flow rate indicates the maximum air consumption when the component under test is closed (i.e. leakage at null forward flow rate or relief flow rate).

The leakage rate shall be measured at the inlet port versus the electrical control signal on its full-scale, with increasing electrical control signals, for a given inlet pressure.

The test shall be performed in accordance with ISO 10094-2:2021, 10.2.

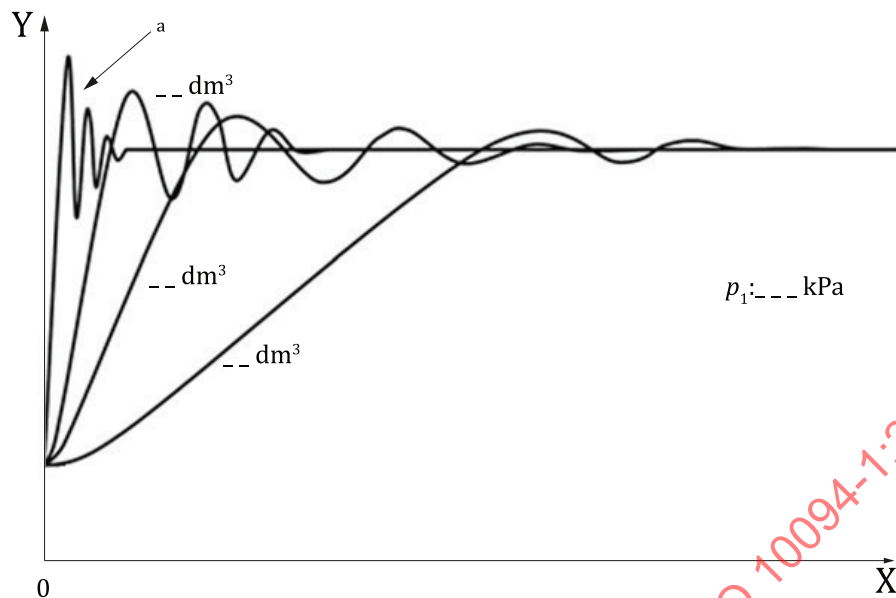
The maximum value of the leakage rate is determined in accordance with ISO 10094-2:2021, 10.3.

5.4 Dynamic characteristics**5.4.1 General**

The dynamic tests proposed in this subclause with different tanks correspond to a global dynamic characterization of the pressure control valve and the tank. It is usually used because it gives to the user an order of magnitude of the global time response for different tank volumes.

5.4.2 Charge characteristics

The time evolutions of the pressure, during the charge of four volumes, by the component under test shall be indicated by curves on a graph, for a given inlet pressure indicated as a relative value as shown in [Figure 5](#). Note that the pressure response can oscillate only for some volume values over the four under test.

**Key**

X time, in s

Y tank pressure, in kPa

 p_1 inlet pressure

a Pressure sensor directly connected.

Figure 5 — Dynamic characteristics of charge

The choice of the tanks and the test procedure are performed in accordance with ISO 10094-2:2021, 11.2.

The values of the tank volumes shall be noted, as in [Figure 5](#).

The characteristic curves shown in [Figure 5](#) are plotted in accordance with ISO 10094-2:2021, 11.3.1.

For each charge test, the shifting time, the response time, the settling time and the possible overshoot are determined in accordance with ISO 10094-2:2021, 11.3.3 and reported as stated in [Table 2](#).

Table 2 — Charge and discharge characteristics

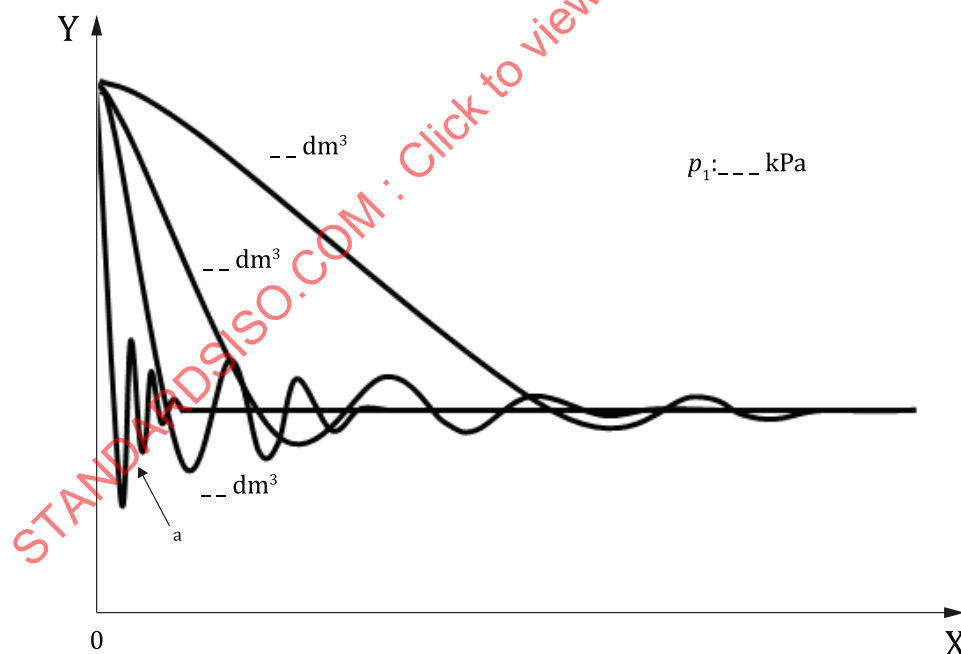
Type of dynamic tests	Dynamic characteristics	Tank			
		Volume 0	Volume 1	Volume 2	Volume 3
Step 1: 0 % to 100 %					
Charge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Overshoot (%)				
Discharge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
Step 2: 25 % to 75 %					
Charge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Overshoot (%)				

Table 2 (continued)

Type of dynamic tests	Dynamic characteristics	Tank			
		Volume 0	Volume 1	Volume 2	Volume 3
Discharge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Undershoot (%)				
Step 3: 45 % to 55 %					
Charge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Overshoot (%)				
Discharge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Undershoot (%)				

5.4.3 Discharge characteristics

The time evolutions of the pressure during the discharge of four volumes by the component under test shall be indicated by curves on a graph, for a given inlet pressure indicated as a relative value as shown in Figure 6. Note that the pressure response can oscillate only for some volume values among the four under test.



Key

X time, in s

Y tank pressure, in kPa

p_1 inlet pressure

^a Pressure sensor directly connected.

Figure 6 — Dynamic characteristics of discharge

The choice of the tanks and the test procedure are performed in accordance with ISO 10094-2:2021, 11.2.

The values of the tank volumes shall be noted, as in [Figure 6](#).

The characteristic curves shown on [Figure 6](#) are plotted in accordance with ISO 10094-2:2021, 11.3.2.

For each discharge test, the shifting time, the response time, the settling time and the possible undershoot (for intermediary steps) are determined in accordance with ISO 10094-2:2021, 11.3.4 and reported as stated in [Table 2](#).

5.4.4 Frequency responses (optional)

5.4.4.1 Characteristics curves

For a given tank volume, V , the variations of the amplitude and phase-lag of the tank pressure signal in relation to the electrical control signal shall be indicated according to the Bode diagrams, depending on the frequency, as shown in [Figure 7](#). The tank volume, as well as the given inlet pressure, shall be noted on the characteristic figure as shown in [Figure 7](#).

This graph shall include at least three different electrical control signal amplitudes for a given inlet pressure indicated as a relative value as shown in [Figure 7](#).

The choice of the tank volume, the selection of the electrical control signal amplitudes and the test program shall be performed in accordance with ISO 10094-2:2021, A.2.

These values of the amplitudes shall be indicated, as shown on [Figure 7](#). If 1 Hz is too high, the minimum value of the abscissa may be given as 10^{-1} Hz.

Each curve shown on [Figure 7](#) shall be plotted in accordance with ISO 10094-2:2021, A.3.