BS ISO 10094-1:2010

BSI Standards Publication

Pneumatic fluid power — Electro-pneumatic pressure control valves

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

National foreword

This British Standard is the UK implementation of ISO 10094-1:2010.

The UK participation in its preparation was entrusted to Technical Committee MCE/18/-/5, Control components.

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INTERNATIONAL STANDARD

ISO 10094-1

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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

Reference number
ISO 10094-1:2010(E)

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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.

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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.

ISO 10094-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 5, *Control products and components*.

ISO 10094 consists of the following parts, under the general title *Pneumatic fluid power — Electro-pneumatic pressure control valves*:

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

— *Part 2: Test methods to determine main characteristics to include in the supplier's literature*

Introduction

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

When it is required to track precisely a variable pressure set point or when precise pressure regulation is needed, electro-pneumatic continuous pressure control valves can be used.

These control valves continuously modulate the pneumatic power 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.

INTERNATIONAL STANDARD **ISO 10094-1:2010(E)**

Pneumatic fluid power — Electro-pneumatic pressure control valves —

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

1 Scope

This part of ISO 10094 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,

— pressure proportional control valves, and

— pressure servo-valves (closed loop).

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.

NOTE 3 This part of ISO 10094 is limited to the characterization of components with an exhaust port to the atmosphere.

2 Normative references

The following referenced 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.

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 10094-2:2010, *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 6953-1 and the following apply.

3.1
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

3.2
inlet pressure
pressure at inlet port of a component, piping or system

3.3
electrical control signal
electrical signal applied to a control device, also called set signal

3.4
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

3.5
minimum regulated pressure
pressure at the first point of the control signal/pressure characteristic curve

3.6
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

3.7
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

4 Symbols and units

For the purposes of this document, the symbols and units listed in Table 1 apply.

Table 1 — Symbols and units

Description	Symbol	SI unit
Total relative pressure at the inlet port[a]	p_1	Pa
Total relative pressure at the outlet port[a]	p_2	Pa
Total relative pressure at the exhaust port[a]	p_3	Pa
Hysteresis	H	%
Linearity	L	%
Repeatability	r	—
Resolution	S	—
[a] In accordance with ISO 11727.		

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 to select 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 curve describes the measured regulated pressure versus the electrical control signal on its full scale, 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 10094-2:2010, 7.2.1.

The characteristic straight line shall be plotted in accordance with ISO 10094-2:2010, 7.3.1, taking, for each value of control signal, the mean value of two measured pressures with respectively an increasing and decreasing control signal.

The offset value and the slope 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 10094-2:2010, Equation (1).

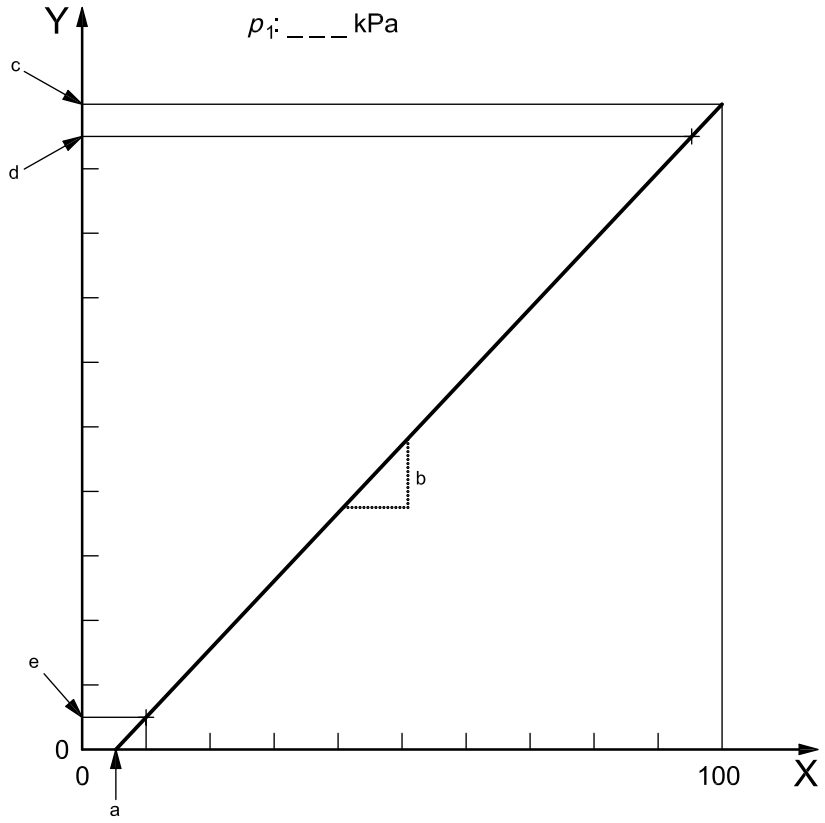
The obtained value gives the maximum difference between the regulated pressure mean values and the characteristic straight line shown in Figure 1.

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 10094-2:2010, Equation (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.



Key

X	electrical control signal, %	a	Offset.	d	95 % of $p_{2,\ max.}$
Y	regulated pressure p_2, in kPa	b	Slope.	e	5 % of $p_{2,\ max.}$
p_1	inlet pressure	c	$p_{2,\ max.}$		

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

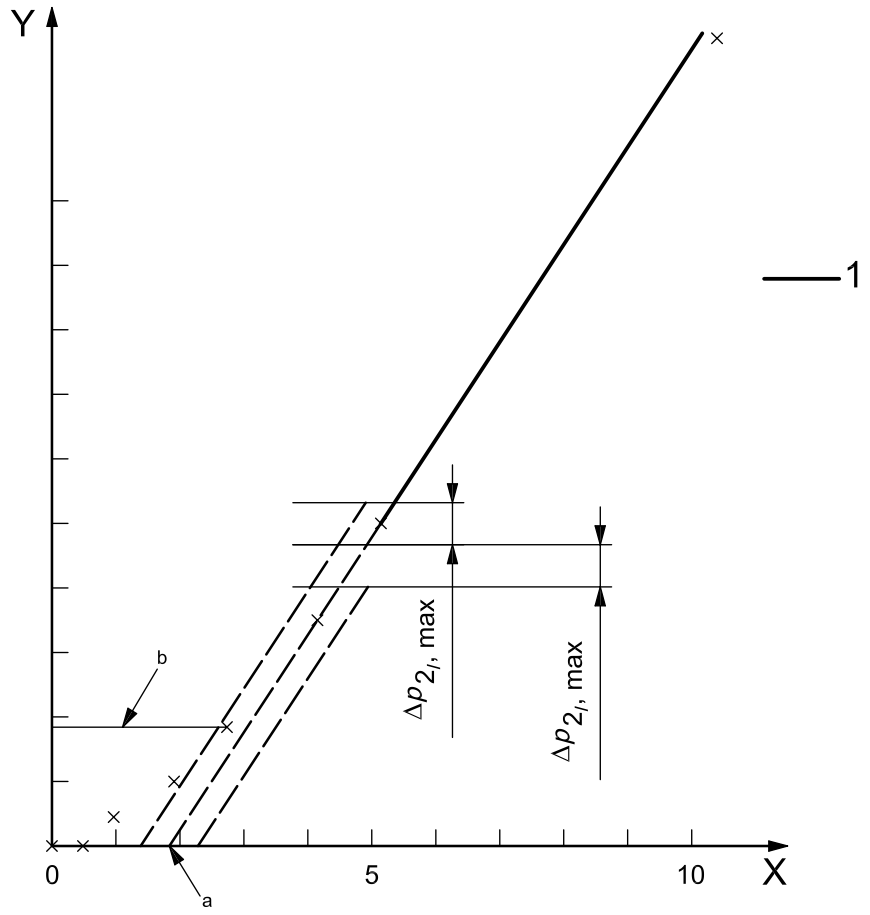
5.3.1.4 Minimum regulated pressure

The test shall be performed in accordance with ISO 10094-2:2010, 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 10094-2:2010, 7.3.4.

The measured points corresponding to the test of ISO 10094-2:2010, 7.2.2, the minimum regulated pressure, as well as the offset, shall be indicated on a graph as shown in Figure 2.



Key

X electrical control signal, %
Y regulated pressure p_2, in kPa
1 characteristic line
a Offset.
b Minimum regulated pressure.

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, Δw, 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 10094-2:2010, 7.2.3.

The resolution, Δw, expressed in percentage of the control signal full-scale, shall be determined in accordance with ISO 10094-2:2010, 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 10094-2:2010, 7.2.4.

The repeatability, r, expressed as a percentage of the regulated pressure full-scale, shall be determined in accordance with ISO 10094-2:2010, 7.3.6.

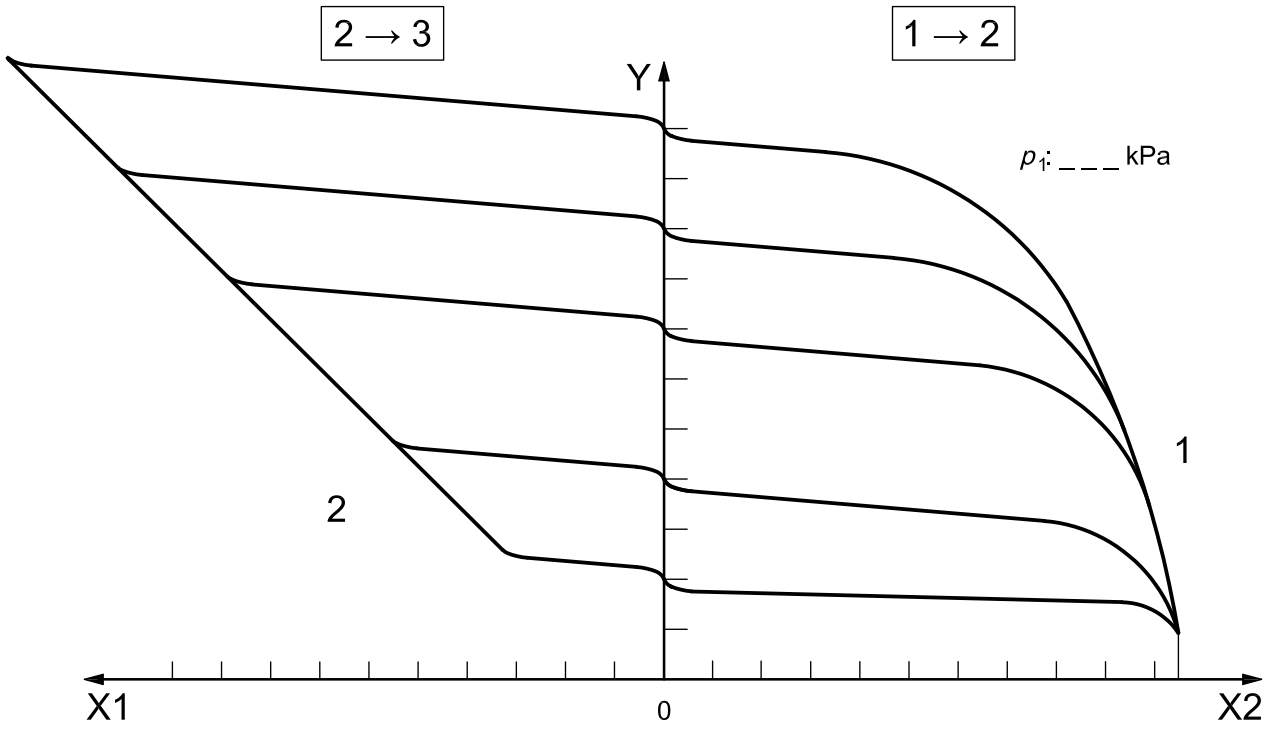
5.3.2 Flow/pressure characteristics

5.3.2.1 Characteristic curves

The regulated pressure shall be indicated by curves according to the graph shown in Figure 3. Each curve will describe 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 10094-2:2010, 8.3.

Each curve shown in Figure 3 is plotted in accordance with ISO 10094-2:2010, 8.4.1, taking, for each value of flow rate, the median value of two pressures measured with respectively increasing and decreasing flow rates.



Key

X1	relief flow rate, in dm^3/s (ANR)	1	1st quadrant
X2	forward flow rate, in dm^3/s (ANR)	2	2nd quadrant
Y	regulated pressure p_2, in kPa	p_1	inlet pressure

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 10094-2:2010, 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 10094-2:2010, 8.4.3.

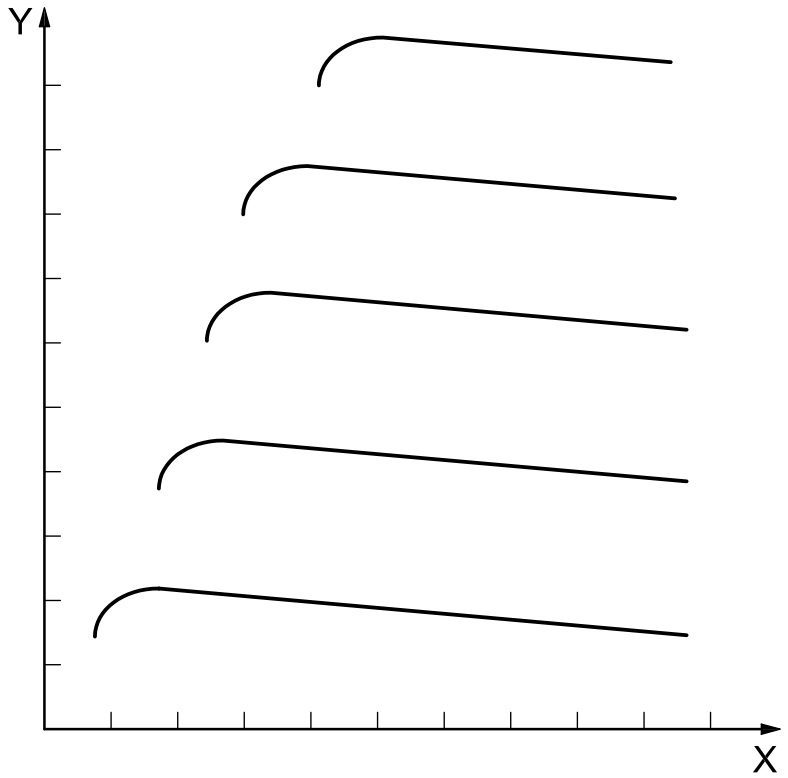
5.3.2.4 Maximum relief sonic conductance

The maximum relief sonic conductance, C_r, is calculated in accordance with ISO 10094-2:2010, 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 will describe 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 10094-2:2010, 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 kPa

Y 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 both increasing and decreasing electrical control signals, for a given inlet pressure.

The test shall be performed in accordance with ISO 10094-2:2010, 10.2.

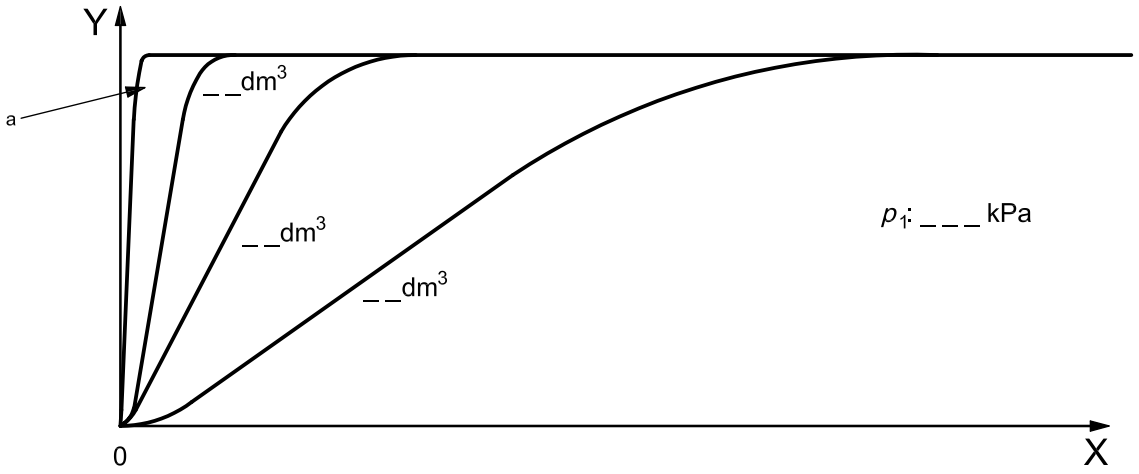
The maximum value of the leakage rate is determined in accordance with ISO 10094-2:2010, 10.3.

5.4 Dynamic characteristics

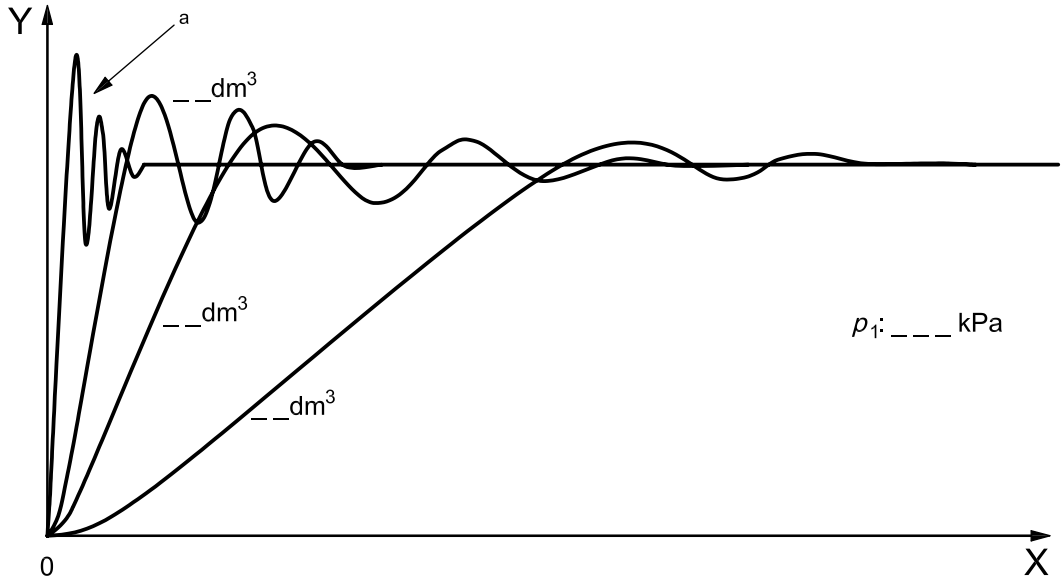
The dynamic tests proposed in this subclause with different tanks correspond to a global dynamic characterization of the pressure control valve and the tank. It is usually used because it gives to the user an order of magnitude of the global time response for different tank volumes. An additional dynamic test is described using a volume that is as small as possible between the valve and the pressure sensor.

5.4.1 Charge characteristics

The time evolutions of the pressure, during the charge of three tanks and with no tank, 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. Figure 5 shows two different configurations showing oscillating behaviour or not. Note that the pressure response can oscillate only for some volume values over the four under test.



a) Case of pressure responses without oscillations



b) Case of pressure responses with oscillations

Key

X time, in s
Y tank pressure, in kPa
p_1 inlet pressure
a Zero volume.

Figure 5 — Dynamic characteristics of charge

The choice of the tanks and the test procedure are performed in accordance with ISO 10094-2:2010, 11.1.2.

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 10094-2:2010, 11.1.3.1.

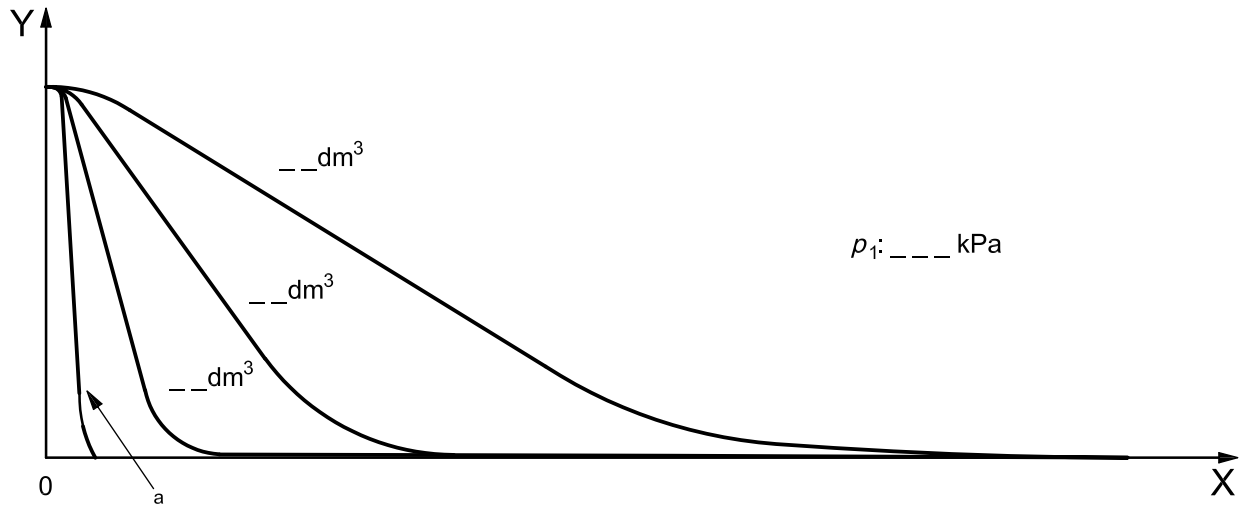
For each charge test, the shifting time, the response time, the settling time and the possible overshoot are determined in accordance with ISO 10094-2:2010, 11.1.3.3 and reported as stated in Table 2.

Table 2 — Charge and discharge characteristics

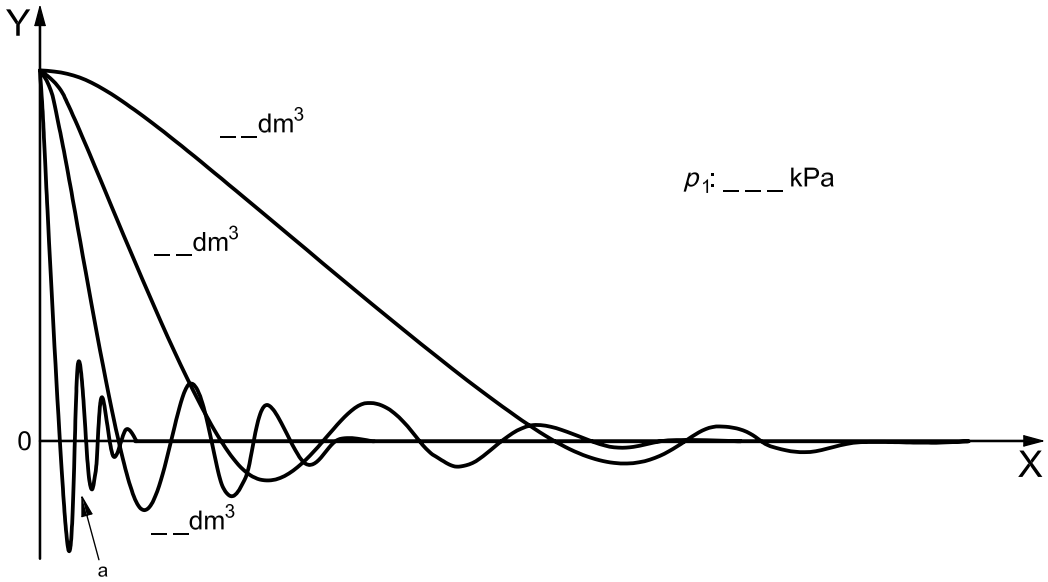
Type of dynamic tests	Dynamic characteristics	Tank			
		No tank	Volume 1	Volume 2	Volume 3
Step 1: 0 % to 100 %					
Charge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Overshoot (%)				
Discharge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
Step 2: 25 % to 75 %					
Charge test	Shifting time (s)				
	Response time (s)				
	Settling time (s)				
	Overshoot (%)				
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 (%)				

5.4.2 Discharge characteristics

The time evolutions of the pressure during the discharge of three tanks and no tank 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. Figure 6 shows two different configurations showing oscillating behaviour or not. Note that the pressure response can oscillate only for some volume values among the four under test.



a) Case of pressure responses without oscillations



b) Case of pressure responses with oscillations

Key

X time, in s

Y tank pressure, in kPa

p_1 inlet pressure

a Zero volume.

Figure 6 — Dynamic characteristics of discharge

The choice of the tanks and the test procedure are performed in accordance with ISO 10094-2:2010, 11.1.2.

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 10094-2:2010, 11.1.3.2.

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 10094-2:2010, 11.1.3.4 and reported as stated in Table 2.

5.4.3 Frequency responses

5.4.3.1 Characteristic curves

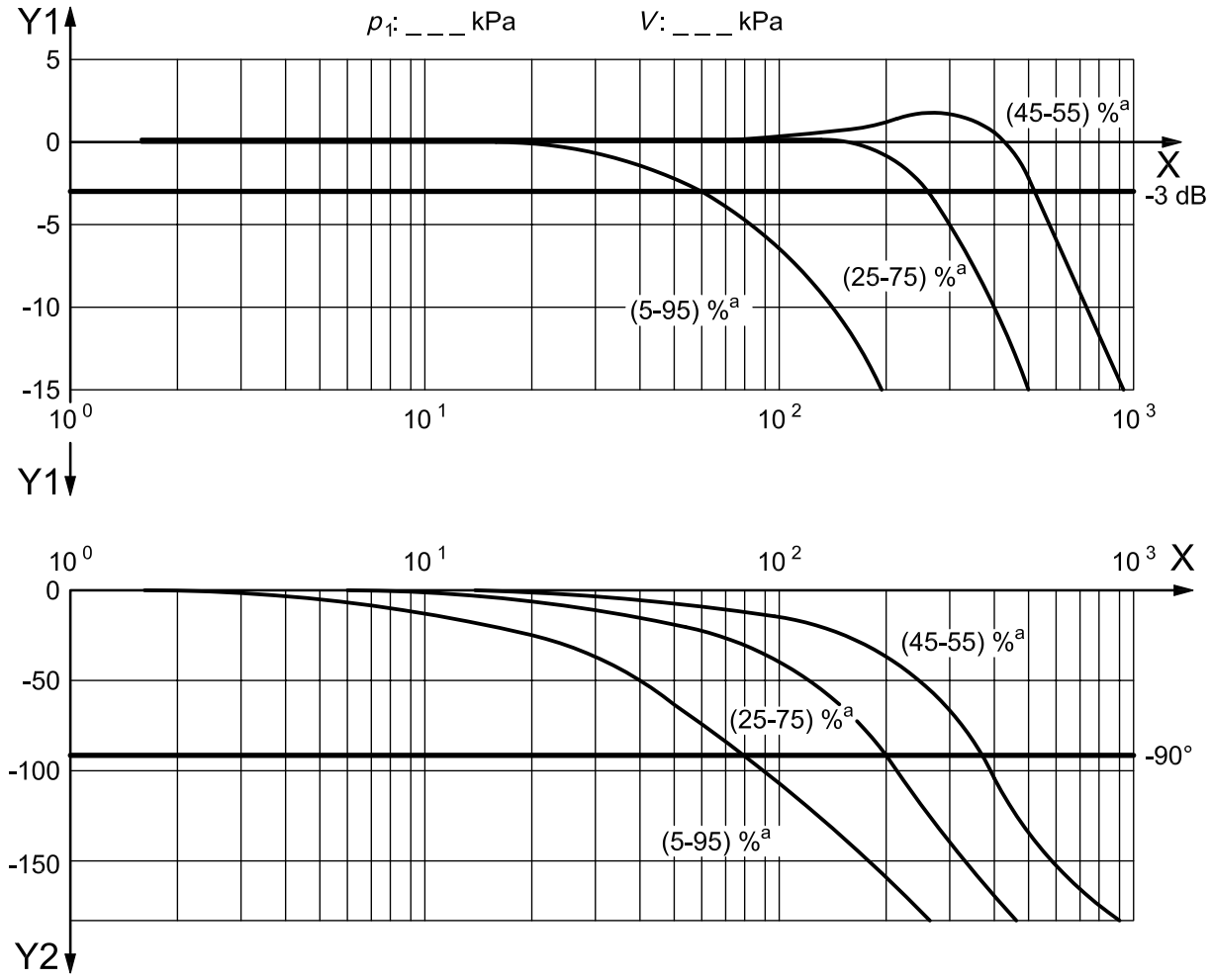
For a given tank volume, V, the variations of the amplitude and phase-lag of the tank pressure signal in relation to the electrical control signal shall be indicated according to the Bode diagrams, depending on the frequency, as shown in Figure 7. The tank volume, as well as the given inlet pressure, 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 10094-2:2010, 11.2.2.

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 10094-2:2010, 11.2.3.



Key

X frequency, in Hz
Y1 amplitude, in dB
Y2 phase lag, in ° (degrees)
V tank volume
p_1 inlet pressure
a Electrical control signal.

Figure 7 — Frequency responses

5.4.3.2 Characteristic frequencies

The frequency values corresponding to respectively 3 dB amplitude attenuation and 90° phase lag shall be reported as stated in Table 3.

This table shall include at least three values of electrical control signal amplitude. These amplitude values and the test program shall be chosen and performed in accordance with ISO 10094-2:2010, 11.2.2.

The determination of these frequencies shall be performed in accordance with ISO 10094-2:2010, 11.2.4.

Table 3 — Characteristic frequencies

Inlet pressure: __ kPa (bar) **Tank volume**: __ dm^3		
Electrical control signal %	**Frequency corresponding to**	
	3 dB amplitude attenuation	**90° phase lag**
45 to 55		
25 to 75		
5 to 95		

6 Identification statement (reference to this part of ISO 10094)

Use the following statement in test reports, catalogues and sales literature when electing to comply with this part of ISO 10094:

"Characteristics and requirements for electro-pneumatic continuous pressure control valves are in accordance with ISO 10094-1:2010, *Pneumatic fluid power — Electro-pneumatic pressure control valves — Part 1: Main characteristics to include in the supplier's literature.*"

Bibliography

[1] ISO 8778, *Pneumatic fluid power — Standard reference atmosphere*

[2] ISO 10041–1:2010, *Pneumatic fluid power — Electro-pneumatic continuous flow control valves — Part 1: Main characteristics to include in the supplier's literature*

[3] ISO 11727, *Pneumatic fluid power — Identification of ports and control mechanisms of control valves and other components*

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