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Pneumatic fluid power — Components using compressible fluids — Determination of flow-rate characteristics

*Transmissions pneumatiques — Éléments traversés par un fluide compressible —
Détermination des caractéristiques de débit*



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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6358 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*.

Annex A forms an integral part of this International Standard. Annexes B, C, D and E are for information only.

Introduction

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

Components composing such a circuit are inherently resistive and affect the flow through it. It is therefore necessary to carry out tests to ascertain the characteristics of these components in order to determine their suitability.

Many components composing a pneumatic circuit operate under conditions of choked flow. This International Standard specifies tests at choked flow in recognition of these conditions.

Pneumatic fluid power — Components using compressible fluids — Determination of flow-rate characteristics

1 Scope

This International Standard specifies a method for testing pneumatic fluid power components which use compressible fluids, i.e. gases, to enable their flow-rate characteristics under steady-state conditions to be compared.

It specifies requirements for the test installation, the test procedure and the presentation of results.

Accuracy of measurement is divided into two classes (A and B) which are explained in annex A.

General background information is given in annex B and the basic theoretical equations are given in annex C. Guidance as to the use of practical units for the presentation of results is given in annex D.

This International Standard generally applies to those fluid power components up to and including 20 mm nominal bore used with compressible fluids (gases), the internal flow passages of which remain constant during testing. Examples of such components are

- a) directional control valves, flow control valves, quick exhaust valves, etc.;
- b) moving part logic devices.

It may also apply to components larger than 20 mm nominal bore but this may require the provision of exceptionally large flow generating equipment.

Two test methods are described according to the type of component. There are also two sets of characteristic constants: C and b ; and A and s , respectively (as defined in 3.2 to 3.5). These may be calculated from the results.

The first set of characteristics (C and b) applies to cases where comparison of similar components is required, or when calculations of pressure and flow involve a single component only.

The second set of characteristics (A and s) is necessary when the flow behaviour of several components which are connected in series is to be estimated. This set may also be used as an optional alternative to the first set for simple flow calculations and for comparison of components.

This International Standard does not apply to components which exchange energy with the fluid (gas), for example cylinders, accumulators, etc.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 228-1 : 1982, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Designation, dimensions and tolerances*.

ISO 261 : 1973, *ISO general purpose metric screw threads — General plan*.

ISO 1179 : 1981, *Pipe connections, threaded to ISO 228-1, for plain end steel and other metal tubes in industrial applications*.

ISO 5598 : 1985, *Fluid power systems and components — Vocabulary*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 5598 and the following definitions apply. It should be borne in mind, however, that the following definitions may differ from those given in other specific International Standards.

3.1 choked flow: Occurrence when upstream pressure, p_1 , is high in relation to the downstream pressure, p_2 , such that the velocity in some part of the component becomes sonic. The mass flow of the gas is proportional to the upstream pressure, p_1 , and independent of the downstream pressure, p_2 .

3.2 critical pressure ratio, b : Pressure ratio (p_2/p_1) below which flow becomes choked.

3.3 sonic conductance, C : Mass flow rate through the component, q_m^* , divided by the product of the upstream

pressure, p_1 , and the mass density at standard conditions ϱ_0 (see table 2) when the flow is choked, i.e.

$$C = \frac{q_m^*}{\varrho_0 p_1} \text{ at } T = T_0$$

NOTE — The numerical value of C depends upon the values chosen for the standard reference atmosphere.

3.4 coefficient of compressibility effect, s : Coefficient which takes into account the effects of the gas compressibility when flow is subsonic (see D.2.3).

3.5 effective area, A : Mass flow rate throughout the component, q_m , divided by the square root of twice the product of the pressure drop, Δp , and the mass density of the gas ϱ_2 , i.e.

$$A = \frac{q_m}{\sqrt{2 \varrho_2 \Delta p}}$$

This applies only when the pressure drop is small in relation to p_1 such that compressibility effects are insignificant, i.e. when $\Delta p/p_1 < 0,02$.

4 Symbols and units

4.1 The symbols and units used throughout this International Standard are as shown in table 1.

Table 1 — Symbols and units

Reference	Description	Symbol	Dimension ¹⁾	SI units ²⁾
3.5	Effective area	A	L^2	m^2
3.2	Critical pressure ratio	b	pure number	
3.3	Sonic conductance	C	$L^4 T M^{-1}$	$s \cdot m^4 / kg$
—	Absolute static pressure (equal to the relative static pressure plus the atmospheric pressure)	p	$M L^{-1} T^{-2}$	$Pa^3)$
—	Mass flow rate	q_m	$M T^{-1}$	kg/s
—	Volume flow rate at standard conditions	q_V	$L^3 T^{-1}$	m^3/s
—	Gas constant (for a perfect gas)	R	$L^2 T^{-2} \Theta^{-1}$	$J/(kg \cdot K)$
3.4	Coefficient of compressibility effect	s	pure number	
—	Absolute temperature	T	Θ	K
—	Pressure drop ($p_1 - p_2$)	Δp	$M L^{-1} T^{-2}$	$Pa^3)$
—	Mass density	ϱ	$M L^{-3}$	kg/m^3

1) M = mass; L = length; T = time; Θ = temperature

2) The use of practical units for the presentation of results is described in annex D.

3) 1 Pa = 1 N/m²

4.2 The numerals used as subscripts and the asterisk (*) used as a superscript to the symbols listed in table 1 are as specified in table 2.

Table 2 — Subscripts and superscripts

Super-script	Sub-script	Meaning
	0	Standard reference conditions, i.e. : $T_0 = 293,15 \text{ K}$; $p_0 = 100 \text{ kPa (1 bar}^{1)})$ 65 % relative humidity
	1	Upstream conditions
	2	Downstream conditions
*		Conditions during sonic flow tests
1) 1 bar = 100 kPa = 0,1 MPa; 1 Pa = 1 N/m ²		

4.3 The graphical symbols used in figures 1 and 2 are in accordance with ISO 1219.

5 Test installation

5.1 Test circuit for components with inlet and outlet ports

A suitable test circuit as shown in figure 1 shall be used.

5.2 Test circuit for components which exhaust directly to atmosphere

A suitable test circuit as shown in figure 2 shall be used.

NOTE — Figures 1 and 2 illustrate basic circuits which do not incorporate all the safety devices necessary to protect against damage in the event of component failure. It is important that those responsible for carrying out the test give due consideration to safeguarding both personnel and equipment.

5.3 General requirements

5.3.1 The test components shall be installed and operated in the test circuit in accordance with the manufacturer's operating instructions.

5.3.2 A filter shall be installed which provides a standard of filtration approved by the test component manufacturer.

5.3.3 A test set-up shall be constructed from the items listed in table 3.

NOTE — Items A to H inclusive are essential and the remaining items I to L are chosen by the experimenter to suit the prevailing conditions.