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AMENDMENT 1
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Pneumatic fluid power — Determination of flow-rate characteristics of components using compressible fluids —

Part 1: General rules and test methods for steady-state flow

AMENDMENT 1: Effective conductance

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

Partie 1: Règles générales et méthodes d'essai en régime stationnaire

AMENDEMENT 1: Conductance effective

Reference number
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Foreword

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

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

Part 1:
General rules and test methods for steady-state flow

AMENDMENT 1: Effective conductance

Scope

Add the following sentence at the end of the paragraph:

A method for evaluating the flow ability of pneumatic components using effective conductance, C_a, is given in Annex I.

Annex I

Add the following annex after Annex H, before the Bibliography.

Annex I
(informative)

Method for evaluating the flow ability of pneumatic components using “effective conductance, C_a”

I.1 General

This annex describes a method for evaluating the flow ability of pneumatic components, taking a global point of view by using a simplified parameter "effective conductance, C_a".

The normal set of four flow-rate characteristic parameters, sonic conductance, C, critical back-pressure ratio, b, subsonic index, m, and cracking pressure, Δp_c, are used to accurately describe the flow-rate characteristics of pneumatic components. However, this annex describes an option for capturing a representative feature of flow characteristics of a component with a single value and for comparing the flow ability of similar components. The flow ability of components using the normal four parameters is complicated. But, the effective conductance, C_a, integrates these four parameters and can be used as a simplified parameter to evaluate the average flow ability of pneumatic components (variation of the back-pressure ratio from 0 to 1).

Although effective conductance, C_a, can compare the flow ability of components easily, it cannot compare them accurately. A cautionary example is shown in Figure I.5.

NOTE 1 This annex does not apply to components that have pressure dependence.

NOTE 2 When the working range of a component is precisely known and in particular when its flow variations are limited, the four flow-rate characteristic parameters given in ISO 6358-1 (this document) and ISO 6358-2 are preferred for comparing similar components.

I.2 Definition of effective conductance, C_a

Effective conductance, C_a, is defined by Formula (I.1). This value is obtained by integrating the conductance characteristic curve of a component and using its average over the range of back-pressure ratios (from 0 to 1), as shown in Figure I.

$$C_a = \int_0^1 C_e \, d\left(\frac{p_2}{p_1}\right) \tag{I.1}$$

where

C_a is the effective conductance in the same units as C_e.

For choked flow, i.e. when $p_2/p_1 \leq b$, Formula (I.2) applies:

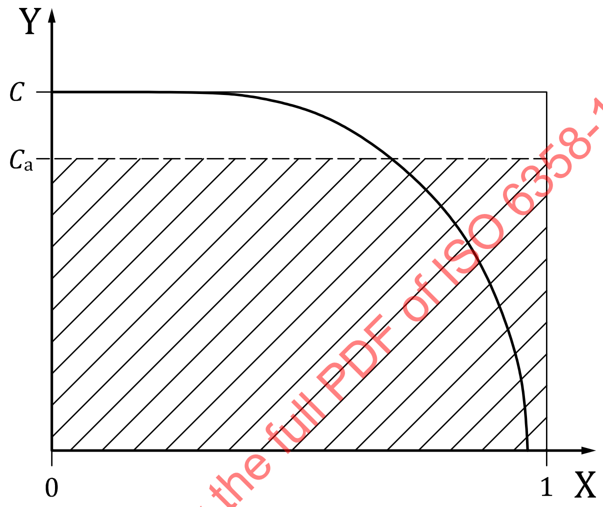
$$C_e = C \tag{I.2}$$

For subsonic flow, i.e. when $b < p_2/p_1 \leq 1-\Delta p_c/p_1$, Formula (I.3) applies:

$$C_e = C\left[1-\left(\frac{p_2/p_1-b}{1-\Delta p_c/p_1-b}\right)^2\right]^m \tag{I.3}$$

For the case when: $1-\Delta p_c/p_1 < p_2/p_1 \leq 1$, then Formula (I.4) applies:

$$C_e = 0 \tag{I.4}$$



Key

X back-pressure ratio, p_2/p_1

Y conductance, C_e

Figure I.1 — Definition of effective condutance, C_a

I.3 Calculation of effective conductance, C_a

Effective conductance, C_a, is calculated using Formula (I.5), based on the Formulae (I.1) to (I.4):

$$C_a = C\left[b+\int_b^{1-\frac{\Delta p_c}{p_1}}\left(1-\left(\frac{p_2/p_1-b}{1-\Delta p_c/p_1-b}\right)^2\right)^m d\left(\frac{p_2}{p_1}\right)\right] \tag{I.5}$$

where the ratio $\Delta p_c/p_1$ is treated as a constant.

As a special case, when m = 0,5, the flow-rate characteristic in the subsonic region is an elliptic function, and the effective conductance, C_a, is calculated using Formula (I.6):

$$C_a = C\left[b + \frac{\pi}{4}\left(1 - \frac{\Delta p_c}{p_1} - b\right)\right] \tag{I.6}$$

As another special case, when m = 1,0, the flow-rate characteristic in the subsonic region is a parabolic function, and the effective conductance, C_a, is calculated using Formula (I.7):

$$C_a = C\left[b + \frac{2}{3}\left(1 - \frac{\Delta p_c}{p_1} - b\right)\right] \tag{I.7}$$

When the working range of pressure ratio of a component is precisely known and, particularly, when its variation is limited, the four flow-rate characteristic parameters are preferable for comparing similar components.

I.4 Judgment of component flow ability

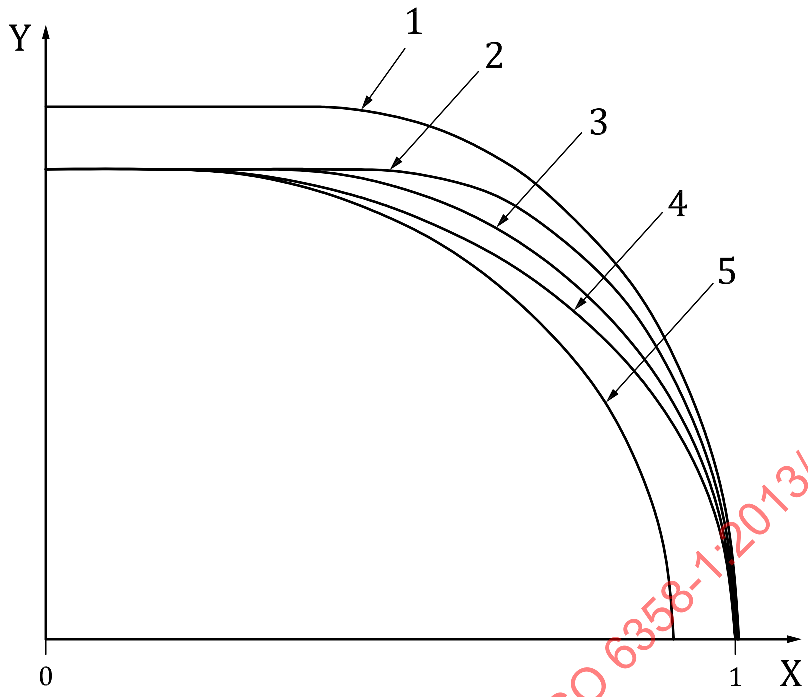
I.4.1 Judgment of ranking

Figure I.2 shows the flow-rate characteristics of five components. The larger the values C and b, and the smaller the values m and Δp_c, the larger will be the value C_a, i.e. it can be understood how the flow ability of the component could be greater. The ranking order of the flow ability for five components is regarded as Component 1 > Component 2 > Component 3 > Component 4 > Component 5. This is also described in the Introduction to this document. This confirms the order of priority given in the Introduction of this document when comparing pneumatic components and recalled here:

— C values have to be compared first,

— for a same C value, b has to be compared first,

then m and Δp_c have to be compared.



Key

X back-pressure ratio p_2/p_1

Y conductance C_e

1 component 1: larger C

2 component 2: larger b

3 component 3: smaller m

4 component 4: smaller Δp_c

5 component 5: larger Δp_c

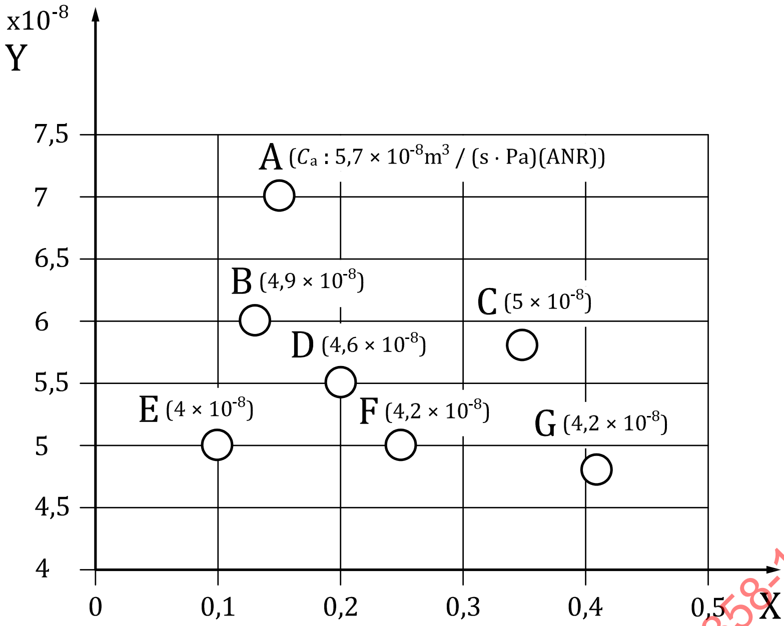
NOTE Flow ranking for Component 1 > Component 2 > Component 3 > Component 4 > Component 5.

Figure I.2 — Component flow ability

I.4.2 Example of ranking

Figure I.3 shows the test results of 5-port directional control valves from seven manufacturers, which are compliant with size 1 of ISO 5599-1. The ranking order of sonic conductance is A>B>C>D>E=F>G. However, when effective conductance, C_a, is used, it will be judged to be A>C>B>D>F=G>E. Thus, the ranking of components whose flow-rate characteristics are different from each other can be judged by the single value of effective conductance, C_a. Thus, the component flow ability can be easily compared.

Figure I.4 shows the corresponding conductance characteristic curves of the 5-port directional control valves shown in Figure I.3. It confirms that when comparing pneumatic components, it is not sufficient to compare only the sonic conductance, because in the subsonic region, a component with a lower sonic conductance can show locally (for a certain range of back-pressure ratio) a better flow ability due to a larger value of b. This is the case when comparing components B and C, or components E, F and G in the subsonic region. Looking at effective conductance, C_a, is a simple way to compare the components globally, but when the working range of pressure ratio of a component is precisely known and, particularly, when its variation is limited in the subsonic region, Figure I.4 confirms that the four flow-rate characteristic parameters are preferable for comparing similar components. A simple method is then to compare graphically the conductance curves as shown in Figure I.4.



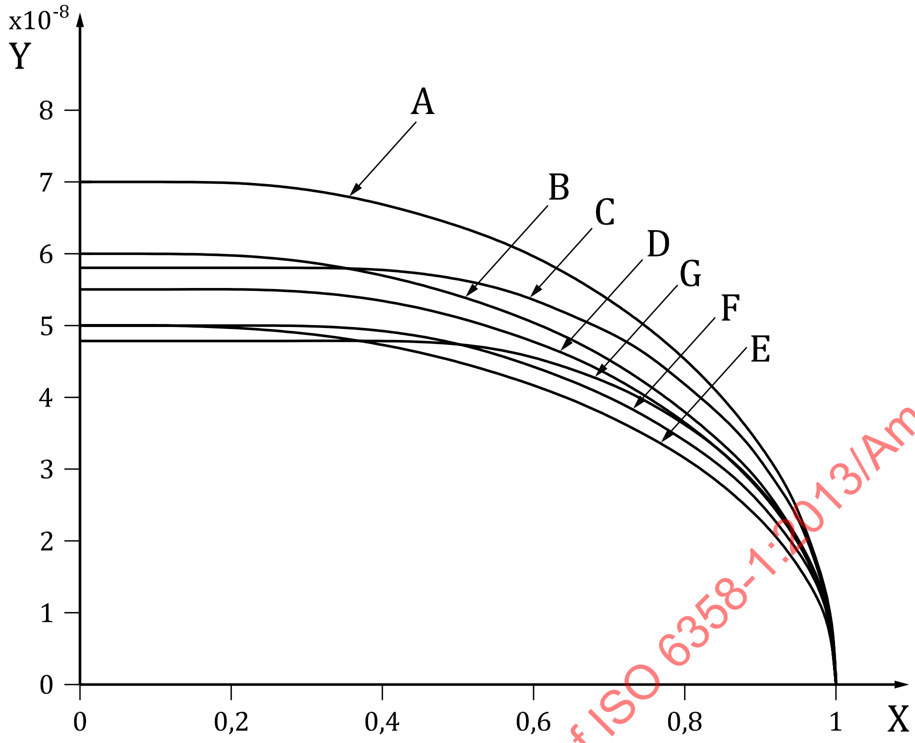
Key

X critical back-pressure ratio, *b*

Y conductance, C_e [m^3/(s·Pa)(ANR)]

A - G 5-port directional control valves from 7 manufacturers

Figure I.3 — Ranking of 5-port directional control valves (m = 0,5, $\Delta p_c/p_1$ = 0)



Key

X back-pressure ratio p_2/p_1

Y conductance, C_e [m^3/(s·Pa)(ANR)]

A - G 5-port directional control valves from 7 manufacturers

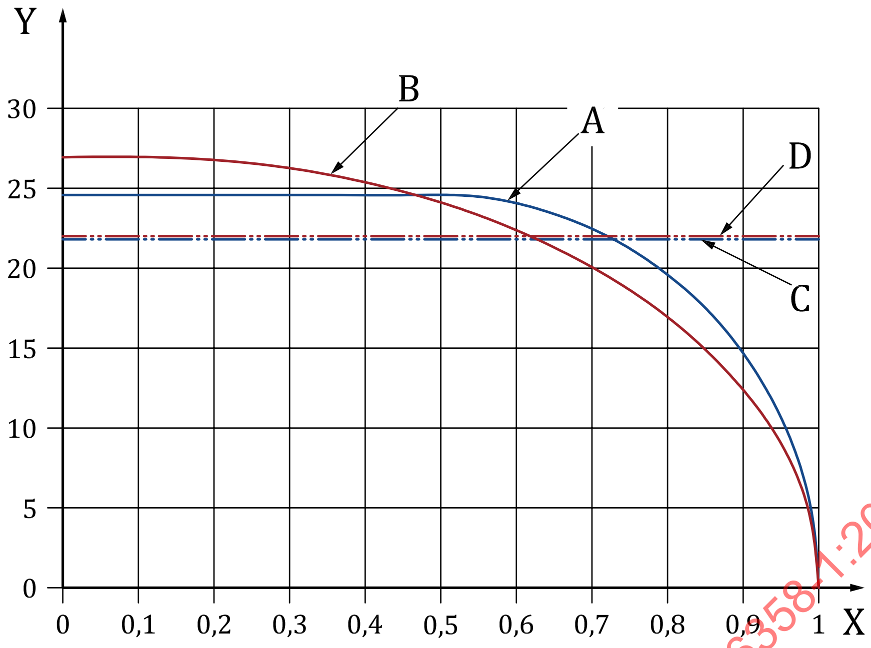
Figure I.4 — Conductance characteristic curves of 5-port directional control valves

I.4.3 Cautionary notes

When effective conductance, C_a, is used, the following phenomenon occurs. Figure I.5 shows the flow-rate characteristics of valves V1 and V2 which have the same effective conductance but different flow-rate characteristics. At lower pressure ratios, valve V2 will flow more air than valve V1. However, valve V1 flows more air at higher pressure ratios. But, it will choke sooner than valve V2.

Figure I.6 shows the pressure response curve of valves V1 and V2 when compressed air is charged to the volume, from atmospheric pressure to 6 bar. Even if both valves have the same effective conductance, the pressure response curve is different. Valve V2 will initially charge more rapidly, but the pressure will rise more slowly as the process continues. Valve V1, on the other hand, will fully charge the tank more rapidly than valve V2.

Therefore, effective conductance, C_a, can be useful for comparing valves to one another, but the actual characteristics of the valves should be used for an application.



Key

X back-pressure ratio, p_2/p_1

Y flow-rate, q [L/s(ANR)]

A valve V1: C = 3,5, b = 0,5

B valve V2: C = 3,85, b = 0,1

C integrated value of valve V1

D integrated value of valve V2

Figure I.5 — Flow-rate characteristics of valves V1 and V2