

BS EN 1751:2014



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Ventilation for buildings — Air terminal devices — Aerodynamic testing of damper and valves

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National foreword

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- Aerodynamische Prüfungen von Drossel- und
Absperrelementen

This European Standard was approved by CEN on 9 November 2013.

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Foreword

This document (EN 1751:2014) has been prepared by Technical Committee CEN/TC 156 “Ventilation for buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2014, and conflicting national standards shall be withdrawn at the latest by July 2014.

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1 Scope

This European Standard specifies methods for the testing and rating of dampers and valves used in air distribution systems with pressure differences up to 2 000 Pa.

The tests incorporated in this European Standard are:

- a) leakage past a closed damper or valve (for classification see Annex C);
- b) casing leakage (for classification see Annex C);
- c) flow rate/pressure requirement characteristics;
- d) torque: (see Annex A);
- e) thermal transmittance: (see Annex B).

The acoustic testing of dampers and valves is not included in this European Standard.

The tests specified above apply to the following:

- f) measurement of leakage past a closed damper or valve;
- g) measurement of casing leakage;
- h) determination of flow rate and pressure requirements;
- i) measurement of torque characteristics (see Annex A);
- j) measurement of thermal transfer characteristics to determine insulation properties (see Annex B).

NOTE Certain aspects of the dynamic performance of dampers or valves are dependent upon the air distribution system to which they are connected and are, therefore, difficult to measure in isolation. Such considerations have led to the omission of these aspects of the dynamic performance measurements from this European Standard. Also, in common with other air distribution components, the results from tests carried out in accordance with this European Standard may not be directly applicable if the damper or valve is situated in an area of non-uniform flow.

2 Normative references

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

EN 12792, *Ventilation for buildings - Symbols, terminology and graphical symbols*

EN ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements (ISO 5167-1)*

EN ISO 5167-2, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates (ISO 5167-2)*

EN ISO 5167-3, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 3: Nozzles and Venturi nozzles (ISO 5167-3)*

EN ISO 5167-4, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 4: Venturi tubes (ISO 5167-4)*

3 Terms, definitions, symbols and suffixes

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12792 apply.

3.2 Symbols

The symbols used in this document are given in Table 1.

Table 1 — Symbols

Symbol	Quantity	Unit
A	Internal cross-sectional area of duct	m^2
C_D	Coefficient of discharge	-
D_e	Equivalent hydraulic diameter Circular ducts: $\sqrt{\frac{4A}{\pi}}$ Square/Rectangular ducts: $\frac{2ab}{a+b}$	m
p	Absolute pressure	Pa
p_a	Atmospheric pressure	Pa
p_d	Velocity pressure $1/2 \rho v^2$	Pa
p_t	Stagnation or absolute total pressure	Pa
p_s	Static gauge pressure ($p - p_a$)	Pa
Δp_s	Pressure difference across the damper or valve under test	Pa
Δp	Flow meter differential pressure	Pa
Δp_t	Conventional total pressure difference for an air density of $1,2 \text{ kg}\cdot\text{m}^{-3}$ at the inlet to the damper or valve under test	Pa
q_v	Volume rate of air flow at the flow meter	$\text{l}\cdot\text{s}^{-1}$
q_{vL}	Leakage volume rate of air flow	$\text{l}\cdot\text{s}^{-1}$
q_{vLBA}	Closed blade air leakage factor, volume rate of air flow per unit duct cross sectional area	$\text{l}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$
q_{vLCA}	Case air leakage factor, volume rate of air flow per reference casing area (which is taken as perimeter of damper multiplied by an equivalent length of 1 m)	$\text{l}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$
v	Velocity	$\text{m}\cdot\text{s}^{-1}$

Symbol	Quantity	Unit
s	Position of damper setting	%, α or m
T	Torque	N·m
U	Thermal transmittance coefficient	$W \cdot K^{-1} \cdot m^{-2}$
q	Temperature	$^{\circ}C$
ρ	Air density	$kg \cdot m^{-3}$
ξ	Pressure loss coefficient	-

3.3 Suffixes

The following suffixes shall be used with the symbols given in Table 1.

- 1 is the inlet of the damper or valve under test;
- 2 is the outlet of the damper or valve under test;
- u is the measuring point upstream of the flow meter;
- n is the value at a selected point of the flow rate/static pressure curve.

4 Instrumentation

4.1 Air flow rate measurement

4.1.1 The air flow rate shall be measured using instruments in accordance with EN ISO 5167-1, EN ISO 5167-2, EN ISO 5167-3 and EN ISO 5167-4, or other instruments which have equivalent calibrated performance.

4.1.2 Air flow meters shall have a minimum calibration accuracy of $\pm 2,5$ % over the whole range.

NOTE If necessary, flow meters can be calibrated *in situ* by means of the Pitot static tube traverse technique described in ISO 3966.

4.1.3 Flow meters shall be checked at intervals as appropriate but not exceeding 12 months. This check can take the form of one of the following:

- a) a dimensional check for all flow meters not requiring calibration;
- b) a calibration over their full range using the original method employed for the initial calibration of meters calibrated *in situ*;
- c) a check against a flow meter which meets flow meter specifications according to EN ISO 5167-1, EN ISO 5167-2, EN ISO 5167-3 or EN ISO 5167-4 as appropriate.

4.1.4 Leakage air flow meters shall have a minimum indicated accuracy according to the ranges in Table 2.

Table 2 — Accuracy of leakage air flow meters

Range $l \cdot s^{-1}$	Accuracy of measurement
Up to and including 0,018	$\pm 0,000\ 9\ l \cdot s^{-1}$
More than 0,018	± 5 %

NOTE Alternatively, other devices such as variable area, flow-rate meters or integrating air flow meters of the positive displacement type can be used if calibrated in accordance with 4.1.3 c).

4.2 Pressure measurement

4.2.1 Pressure in the duct shall be measured by means of a liquid filled, calibrated manometer or any other device conforming to 4.2.2.

4.2.2 The resolution shall not be greater than the characteristics listed for the accompanying range of manometers, given in Table 3.

Table 3 — Resolution for the ranges of manometers

Range Pa	Resolution Pa
Up to and including 50	0,1
From 50 to 250	1
From 250 to 500	5,0
Above 500	25,0

4.2.3 The measured value of differential pressure should be greater than 10 % of the range of the measurement device used.

EXAMPLE With a micromanometer with a range from 0 to 1 000 Pa the minimum differential pressure to be measured is 100 Pa.

4.2.4 The uncertainty of calibration standards shall be:

- a) for instruments with a measuring range up to 100 Pa, equal or better than $\pm 0,5$ Pa;
- b) for instruments with a measuring range over 100 Pa, equal or better than $\pm 0,5$ % of reading.

4.3 Temperature measurement

Measurement of temperature shall be, for example, by means of mercury-in-glass thermometers, resistance thermometers or thermo-couples. Instruments shall have a resolution better than 0,5 K and be calibrated to an accuracy of $\pm 0,25$ K.

5 Leakage tests

5.1 General

Damper leakage performance could vary depending on whether the damper is subjected to positive or negative pressure. The manufacturer shall specify the pressure conditions for test.

5.2 Damper and valve leakage

5.2.1 Measurement of damper and/or valve leakage in the shut-off position shall be made under conditions of actual operation with the damper or valve closing against the maximum recommended static pressure conditions. Since small flow rates exist during the closed damper or valve condition, the method used to measure these small flow rates will introduce a high pressure loss when the damper or valve is open. This precludes a high pressure difference in the inlet duct until the damper or valve approaches the closed position.

As the valve is closed and the flow rate decreases, the inlet static pressure difference will increase to approximately the recommended inlet pressure.

5.2.2 The damper or valve shall be cycled 10 times between the fully open and fully closed positions of the actuator at the start of each test (before starting the fan of the air supply system) concluding with the damper or valve in the fully closed position.

NOTE In all cases in the closed position, the damper drive is subject to a torque rating recommended by the manufacturer.

5.2.3 The damper or valve under test shall be connected to a test installation similar to that shown in Figure 1a) or Figure 1b)). A suitable air supply shall be connected to the duct. In both cases, care shall be taken to ensure that duct joints are sealed to manufacturer's instructions.

5.2.4 The supply air pressure shall be increased to the maximum recommended inlet pressure difference in accordance with the appropriate classification from Figure C.1 and Figure C.2. The damper or valve is then modulated to the open position, without any additional adjustment of the supply air system flow rate, and then returned to the closed position either manually or by the means provided by the manufacturer. The supply air pressure shall be adjusted, as the damper or valve nears closure, to maintain the recommended inlet static gauge pressure difference within $\pm 5\%$. The above process is to ensure that the closed condition is as representative as possible of typical operation with airflow present.

NOTE The air flow measuring device for leakage measurement may have to be disconnected in the above process to avoid any potential damage to a device for measuring low air rates.

5.2.5 Report the damper or valve air leakage factor as a function of test pressure difference in the closed position. Also include classification (see Annex C).

5.3 Casing leakage

5.3.1 The test installation shall be similar to that shown in Figure 2 a)) or Figure 2 b)). The damper or valve casing outlet shall be sealed according to the instructions of the manufacturer. The damper or valve shall be set to the open position.

5.3.2 The test of the casing shall be carried out by subjecting the casing to its maximum recommended pressure in accordance with 5.2.4. The pressure shall be maintained for 60 s before the measurement of leakage commences.

5.3.3 Report the test results as casing air leakage factor as a function of test pressure. Also include classification (see Annex C).

6 Flow rate and pressure tests

6.1 Ducted method

6.1.1 This method applies for dampers or valves mounted within a duct.

6.1.2 The damper or valve under test shall be mounted in a system comprising a fan, a means of controlling air flow rate, a flow rate measuring system and test ducts (see Figure 3).

6.1.3 The test ducts shall have cross-sectional dimensions equal to the nominal size of the unit under test or to the manufacturer's instructions. The upstream test duct shall be straight for a minimum length of $5D_{e1}$. The downstream test duct shall be straight for a minimum length of $5D_{e2}$ or 2 m, whichever is the greatest.

6.1.4 Flow straighteners shall be fitted in the upstream test duct at a position $3D_{e1}$ from the connection to the damper or valve under test or, alternatively a straight duct shall be used without a flow straightener.

6.1.5 The velocity profile near the upstream connection to the damper or valve under test shall be uniform to 10 % of the mean value over the test duct cross section, excluding the area within 15 mm of the duct walls. Carry out a velocity survey at ten equally spaced intervals along a pair of mutually perpendicular axes to confirm that the velocity profile is within these limits. Wire mesh screens located no closer than $2,5D_{e1}$ to the upstream connection to the damper or valve under test can, if necessary, be incorporated to achieve a suitably uniform velocity profile.

6.1.6 The upstream duct static gauge pressure (p_{s1}) shall be measured by means of four static pressure tappings $1,5D_{e1}$ from the upstream connection to the damper or valve under test. For a rectangular duct, these pressure taps shall be at the centre of each side and, for a circular duct, equally spaced around the circumference. Connect the pressure taps to form a piezometric ring. Alternatively, use a single Pitot static probe.

6.1.7 The air temperature shall be measured at the flow meter and at a position $2,5D_{e1}$ upstream of the damper or valve under test, and, during the test the temperature variation at the same station shall not be greater than 3 K.

6.1.8 The damper or valve shall be set in its fully open position and tests shall be carried out as follows:

6.1.8.1 Use a minimum of five air flow rates distributed evenly throughout the total flow range, and choose the lowest air flow rate so that the test duct static pressure is not less than 10 Pa.

6.1.8.2 Remove the damper or valve from the test installation and connect the upstream test duct directly to the downstream test duct. Repeat the procedure in 6.1.8 at five air flow rates covering the same flow rate range used in 6.1.8.

6.1.9 If required, repeat the procedure described in 6.1.8 with the damper or valve other than in the open position.

6.1.10 Record the data given in Table 4.

Table 4 — Flow rate and pressure test data

Symbol	Quantity	Unit	Uncertainty of measurement
$p_{s1(a)}$	Inlet duct static gauge pressure with the damper or valve installed	Pa	3 %
$p_{s1(b)}$	Inlet duct static gauge pressure with the damper or valve removed	Pa	3 %
p_a	Atmospheric pressure	Pa	1 %
θ_1	Air temperature at inlet to the damper or valve under test	°C	3 %
Δp^a	Flow meter differential pressure	Pa	3 %
p_{su}	Static gauge pressure immediately upstream of the flow meter	Pa	3 %
θ_u	Air temperature immediately upstream of the flow meter	°C	3 %
S	Position of damper setting	%, α or m	2°
^a Or the appropriate parameter which relates to q_v .			

6.2 Chamber method

6.2.1 General

This method applies for dampers and valves with free inlet and discharge.

6.2.2 Size relationship

The size relationship of test setup apparatus for determination of flow rate and static pressure differential of the device under test shall be limited to the following:

- The chamber cross-sectional area shall be at least 7 times the internal cross sectional area of duct (A) of the device being tested.
- Other dimensions shall respect indications of Figure 4.

6.2.3 Tests

6.2.3.1 Pressure difference according to test chamber method is a statement of the pressure difference required to accelerate the air to a given velocity and overcome any entrance (exit) losses due to the blockage and entrance (exit) conditions.

6.2.3.2 Use a minimum of five air flow rates distributed evenly throughout the total flow range, and choose the lowest air flow rate so that the test duct static pressure is not less than 10 Pa.

6.2.3.3 If required, repeat the procedure described in 6.2.3.2 with the damper or valve other than in the open position.

6.2.3.4 Record the data given in Table 5.

Table 5 —Flow rate and pressure test data

Symbol	Quantity	Unit
Δp_s	Pressure difference across the damper or valve under test	Pa
p_a	Atmospheric pressure	Pa
θ_1	Air temperature at inlet to the damper or valve under test	°C
Δp^a	Flow meter differential pressure	Pa
p_{su}	Static gauge pressure immediately upstream of the flow meter	Pa
θ_u	Air temperature immediately upstream of the flow meter	°C
S	Position of damper setting	%, α or m
^a Or the appropriate parameter which relates to q_v .		

6.3 Test report

6.3.1 The volume air flow rate at the flow meter (q_v) shall be determined for each test. If there are significant differences in the air temperature and static pressure between flow meter and the damper or valve under test so that the air density ratio is less than 0,98 or greater than 1,02, the following correction shall be applied:

$$q_{v1} = q_v \cdot \frac{\rho_u}{\rho_1} \quad (1)$$

where

$$\rho_u = 3,47 \cdot 10^{-3} \left[\frac{P_{su} + P_a}{\theta_u + 273} \right] \quad (2)$$

and

$$\rho_l = 3,47 \cdot 10^{-3} \left[\frac{P_{sl} + P_a}{\theta_l + 273} \right] \quad (3)$$

Otherwise, q_{v1} shall be taken as equal to q_v .

The air density ratio is $\frac{\rho_u}{\rho_l}$.

6.3.2 Having measured values of $p_{s1(a)}$ and $p_{s1(b)}$ and determined corresponding values of q_{v1} in accordance with 6.3.1, plot the following functions on a linear graph:

$$p_{s1(a)} \text{ vs } (q_{v1})^2$$

$$p_{s1(b)} \text{ vs } (q_{v1})^2$$

By graphical or calculation methods determine the best straight line through the plotted points and passing through zero (see Figure 5a)). If isolated points fall outside $\pm 5\%$ differential pressure band about the best mean line, repeat the tests at the relevant flow rates to check validity of test data. If, in the case with the damper fitted, groups of points fall outside the $\pm 5\%$ band indicating the test results do not follow a linear relationship between $(q_{v1})^2$ and $p_{s1(a)}$, draw the best line (curve) through the points and zero (see Figure 5b)). If the $p_{s1(a)}$ points fall within $\pm 5\%$ of the line (curve), the curve can be used for calculation in 6.3.3 and 6.3.4. If the $p_{s1(a)}$ points fall outside $\pm 5\%$ of the curve, only individual test points for $p_{s1(a)}$ can be used in 6.3.3 and 6.3.4 and the situation shall be made clear in reporting the test results in accordance with 6.3.7.

6.3.3 Having complied with 6.3.2:

- a) When $p_{s1(a)}$ vs $(q_{v1})^2$ is a straight line, select a value of flow rate q_{v1n} within the flow rates investigated. The static gauge pressure requirement of the unit under test at this condition is:

$$p_{sn} = p_{s1(a)n} - p_{s1(b)n}$$

- b) When $p_{s1(a)}$ vs $(q_{v1})^2$ is a curve, select a range of q_{v1n} at least three values: a low, medium and high value to determine values of p_{sn} .

6.3.4 Calculate the coefficient C_D as follows using values of p_{sn} from 6.3.3:

$$C_D = \frac{\text{Actual flow}}{\text{Theoretical flow}} \quad 1)$$

1) Theoretical flow is defined as the flow with a loss coefficient $\xi = 1$.

$$= \frac{q_{v1n}}{A_l \left(2 \cdot \frac{p_{sn}}{\rho_{ln}} \right)^{\frac{1}{2}}} \quad (4)$$

where

$$\rho_{ln} = 3,47 \cdot 10^{-3} \left[\frac{p_{sl(a)n} + p_a}{\theta + 273} \right] \quad (5)$$

NOTE 1 C_D is normally only of interest if the damper blades are in the fully open position.

NOTE 2 The relationship between the coefficient of discharge C_D and the loss coefficient ξ is:

$$\xi = \frac{1}{C_D^2} \quad (6)$$

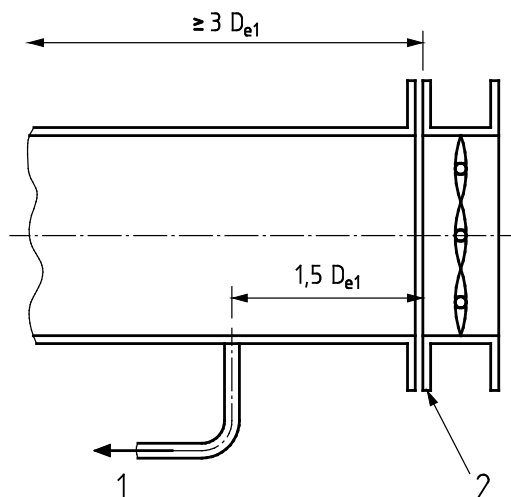
6.3.5 Repeat the tests in 6.1 or 6.2 and the reduction of results as required for a number of intermediate damper blade positions 's'.

6.3.6 Calculate all energy and static pressure losses quoted from the test results using the coefficient of discharge.

6.3.7 Report all the test results as pressure requirements and coefficients of discharge for the flow rates tested and the related values of damper setting 's' if applicable.

NOTE In the context of this European Standard, the damper setting is defined as the angle or position of the blade(s) and/or the physical displacement of the adjustable component(s) in relation to a datum.

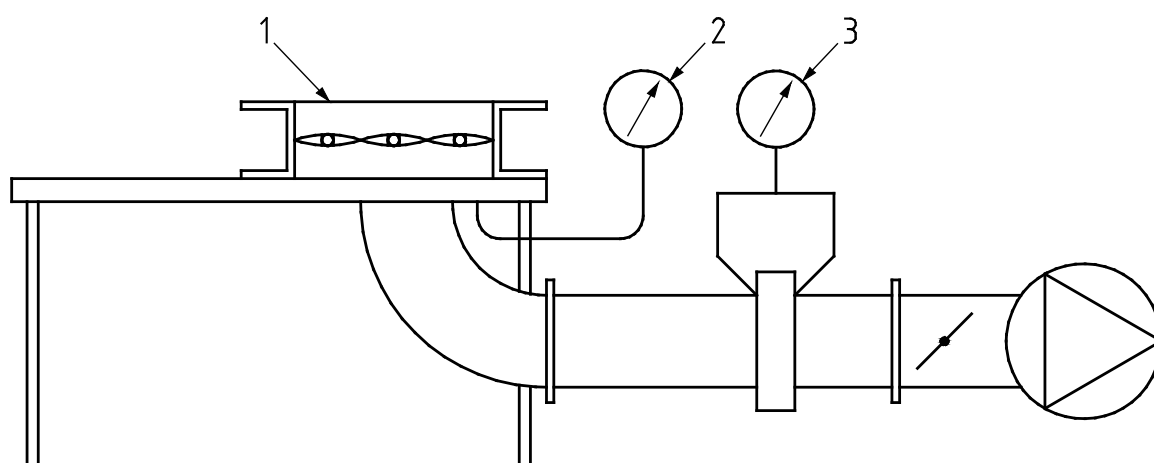
In determining static pressure losses, the damper has ducted inlet and outlet. In using test data for other configurations, i.e. airflow from plenum through damper into a duct, vice versa or plenum/damper/plenum, due allowance should be made for the additional appropriate contraction and/or expansion losses.



Key

- 1 to manometer
- 2 sealed joint

a) Valve or damper leakage

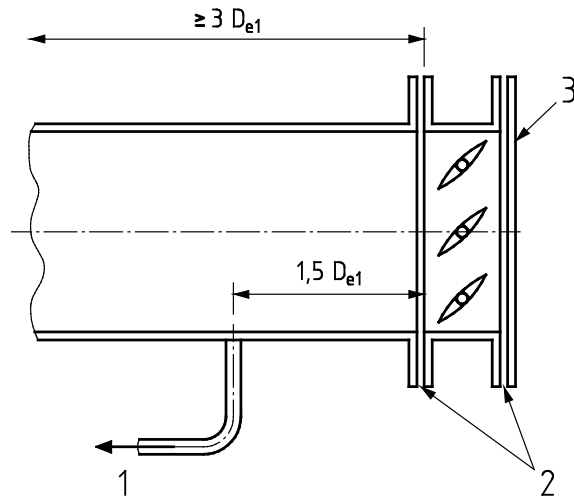


Key

- 1 damper or valve under test
- 2 pressure measurement
- 3 volume air flow measurement

b) Arrangement of alternative damper leakage measurement

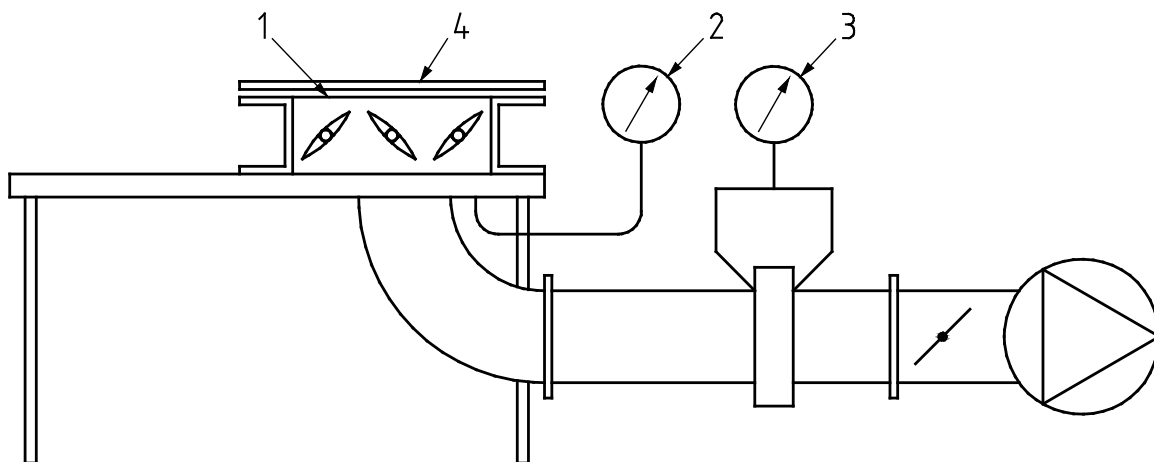
Figure 1



Key

- 1 to manometer
- 2 sealed joints
- 3 blanking plate

a) Casing leakage

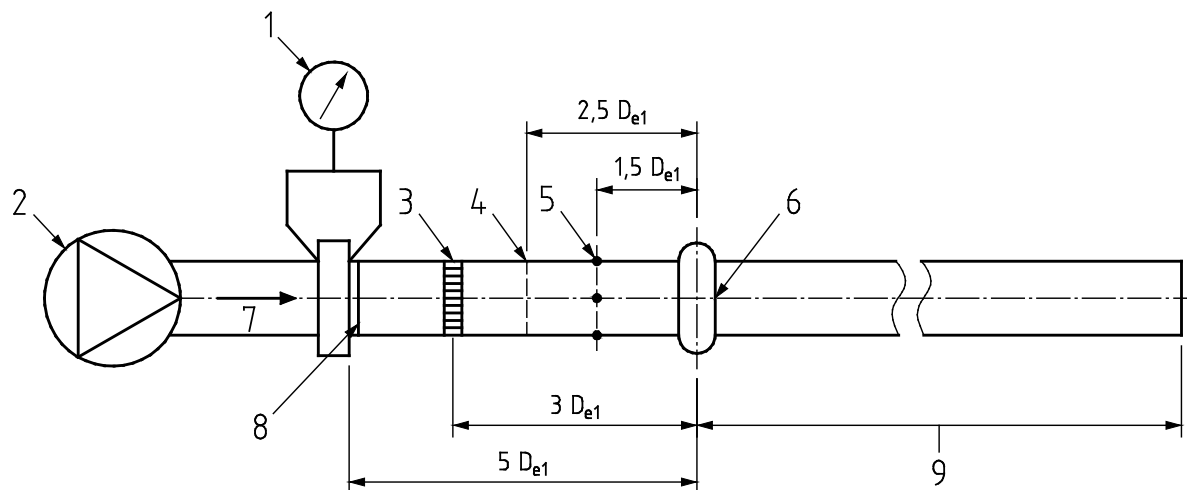


Key

- 1 damper or valve under test
- 2 pressure measurement
- 3 volume air flow measurement
- 4 blanking plate

b) Arrangement of alternative case leakage measurement

Figure 2



Key

- 1 flow measuring station
- 2 fan
- 3 flow straightener
- 4 wire mesh screen if required at min. $2,5D_{e1}$ and temperature measuring point at $2,5D_{e1}$
- 5 4 static taps connected by piezometric ring; alternatively, a probe can be used.
- 6 damper or valve under test
- 7 direction of flow
- 8 connection to flow rate meter, fan and flow rate controller
- 9 $5 D_{e2}$ min. or 2 m (whichever is greater)

Figure 3 — Flow rate/pressure requirement - Typical test arrangement

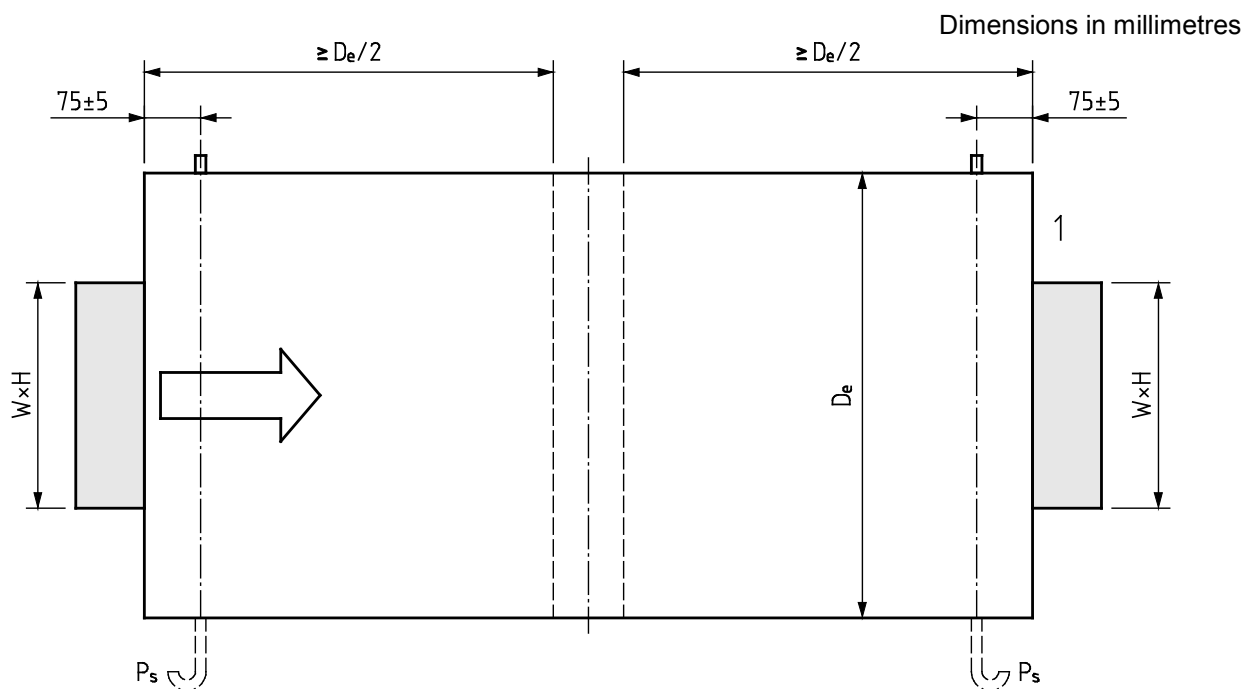
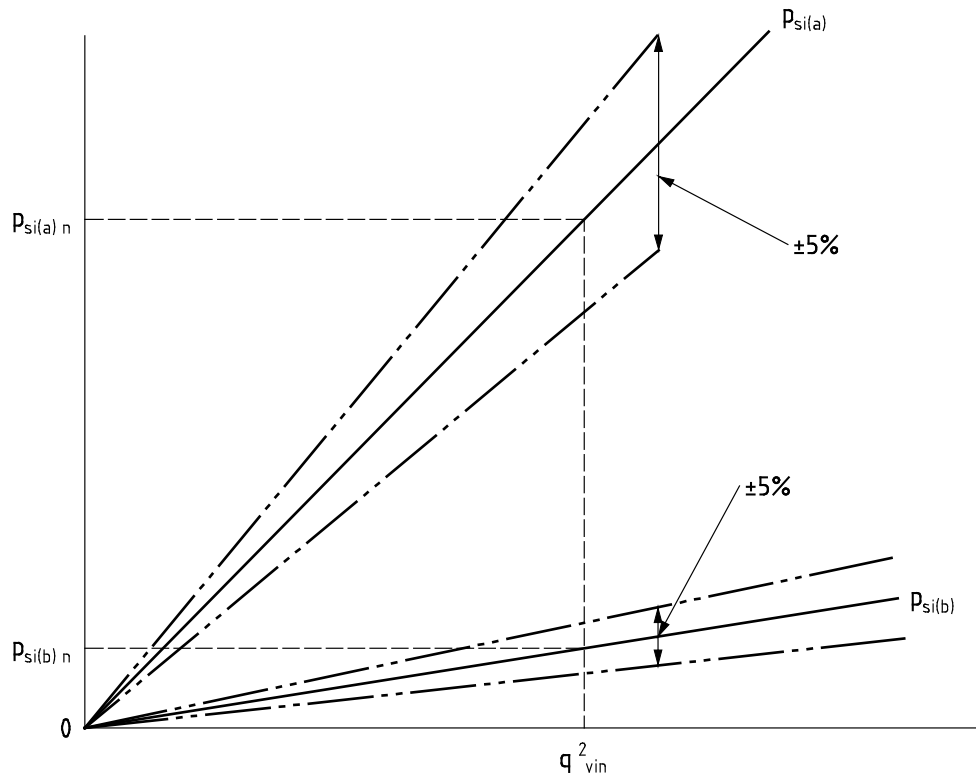
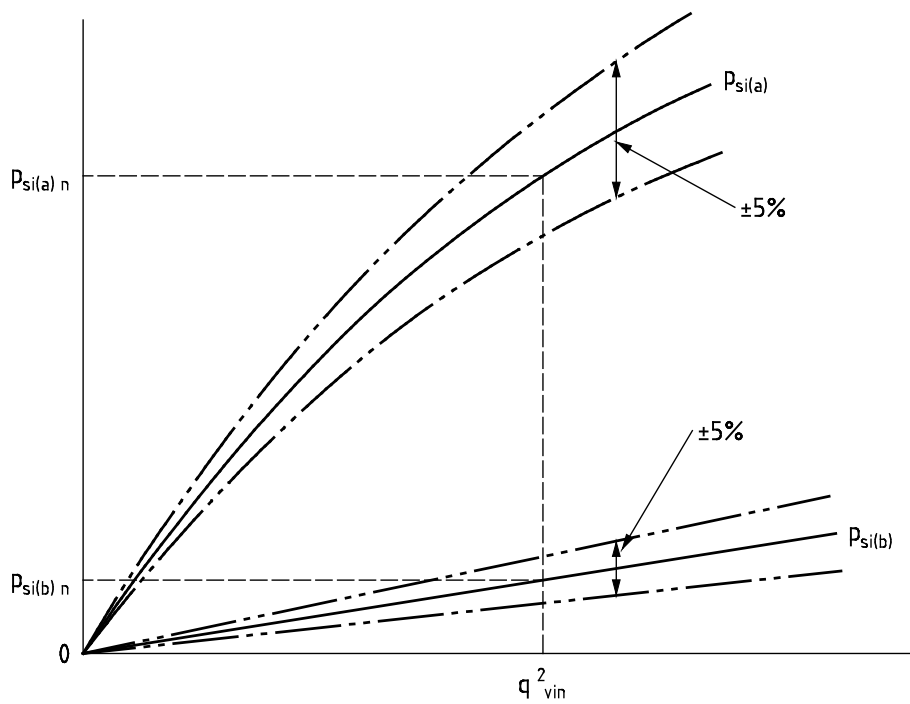


Figure 4 — Test Device Setup with Inlet or Discharge Chamber



a) Flow rate and pressure requirement - Straight line characteristic for $p_{si(a)}$ vs q^2_{vin}



b) Flow rate and pressure requirement - Best line (curve) characteristic for $p_{si(a)}$ vs q^2_{vin}

Figure 5

Annex A (informative)

Mechanical testing of dampers and valves

A.1 Scope

This annex specifies methods for the mechanical testing and rating of dampers and valves described in this European Standard.

The tests incorporated in this annex are:

- a) determination of maximum closed blade duct pressure for mechanical stability of damper;
- b) determination of the torque required to open and close a damper or valve;
- c) determination of maximum permitted torque applied to a damper or valve to avoid structural damage.

A.2 Instrumentation: Torque measurement

A.2.1 The measurement of initial and operating torque can be achieved using either a torque spanner or a lever arm and balance weight. The length of the lever arm and weight or selection of the torque spanner should be such that readings of $\pm 0,5 \text{ N}\cdot\text{m}$ can be achieved.

A.2.2 The torque can also be determined by using a strain gauge transducer attached to the lever mechanism of the actuator. The reading given by the detector should be permanently recorded, e.g. chart recorder.

A.2.3 The equipment of A.2.1 should be calibrated using a lever arm and weight, any bearings used should be of low friction type. The accuracy of calibration should be $\pm 0,2 \text{ N}\cdot\text{m}$, and the reading interval should correspond to a torque of $\pm 0,5 \text{ N}\cdot\text{m}$.

A.3 Pressure test to determine limiting value for structural stability

Use the test configurations as shown in Figure 1 a) or Figure 1 b). With the damper blades closed, increase the static pressure in the duct in steps. Then, remove the static pressure and measure any permanent structural deformation at each zero pressure condition.

When permanent deformation progressively increases at zero pressure after each pressure increment or structural instability (i.e. vibration) at test pressures occurs, report the test pressure for structural instability or the pressure at the commencement of the increase of permanent deformation as X Pa.

A maximum acceptable deformation shall not represent more than 1/250th of the span.

A.4 Torque tests to determine the torque required to operate the damper or valve and the limiting value to avoid structural damage

A.4.1 Torque required to operate damper

A.4.1.1 To determine the required torque, connect the damper or valve to ductwork as in Figure A.1. When the damper is open, adjust the air supply to give duct velocity of $10 \text{ m}\cdot\text{s}^{-1}$. When the damper is closed, adjust the upstream static pressure p_{s1} to:

$$p_{s1} = 0,8 p_{\max} \pm 20 \%$$

where

p_{\max} is the limiting duct pressure determined from A.3.

A.4.1.2 Using the instrumentation of A.2, determine the required torque and pressure difference across the damper Δp for a total of at least six equally spaced damper settings, including fully open and fully closed. Conduct the tests from closed to open and open to closed.

A.4.1.3 Calculate the torque coefficient for each damper setting as follows:

$$a = \frac{T}{\Delta p_t \cdot A} \quad (\text{A.1})$$

where

a is the torque coefficient, in metres;

T is the measured torque, in newton metres at a given damper setting;

Δp_t is the pressure drop across damper, in pascals at a given damper setting;

A is the duct cross sectional area, in square metres.

A.4.1.4 Present the results as a graphical plot of torque coefficient as a function of damper setting.

NOTE To obtain more data points additional open damper air velocities can be used (see Figure A.2 for typical results).

A.4.2 Maximum permitted torque

A.4.2.1 To determine the maximum permissible torque, attach a torque spanner or lever arm and weight system to the damper or valve drive arm or shaft using the same connection as used for the actuator.

A.4.2.2 Using the means of load application in A.4.2.1, progressively increase the load on the damper until permanent deformation of the damper or its linkage, or the manufacturer's limiting torque figure is reached. Conduct this test with the damper fully open and fully closed.

A.4.2.3 Report the test results defining the damper status, i.e. open or closed, and detailing the maximum torque in N·m before permanent deformation or, if lower, the manufacturer's limiting value.

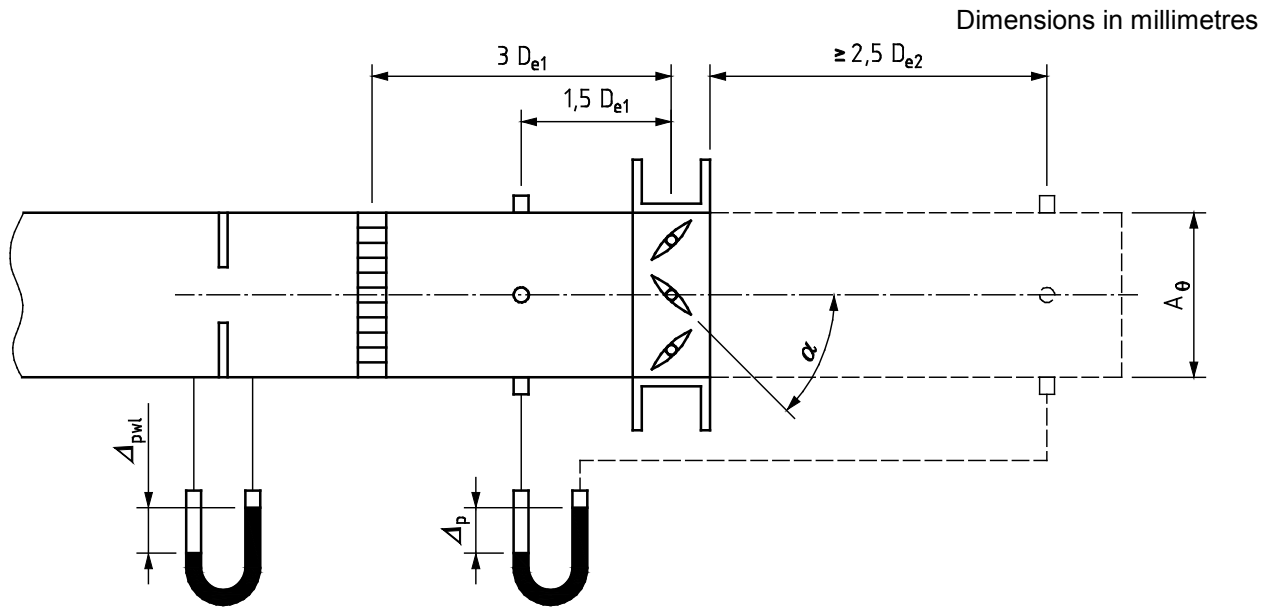
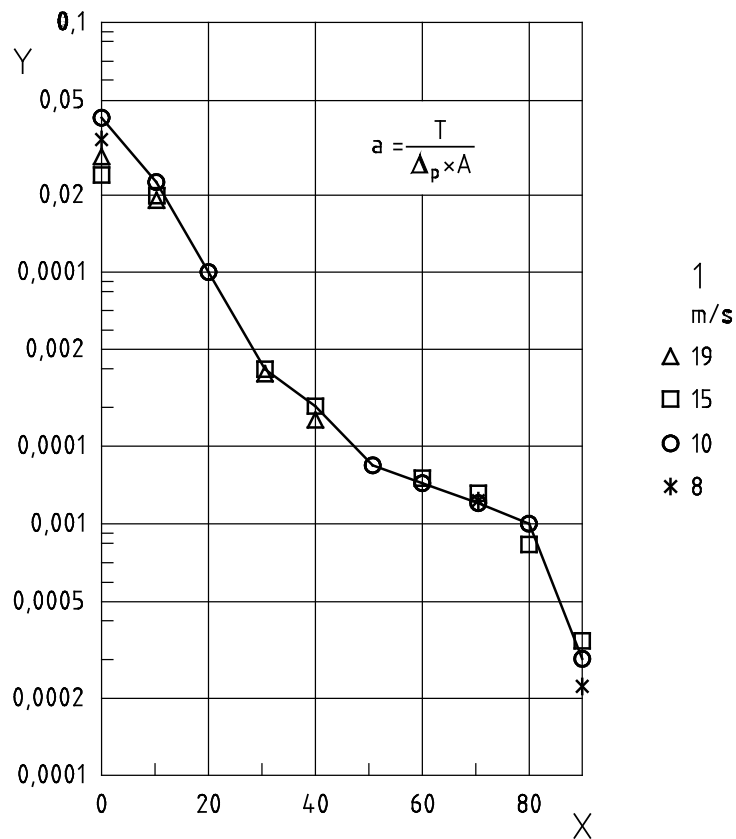


Figure A.1 — Test rig for torque measurement



Key

- 1 open damper velocity
- X blade position, α in degrees
- Y torque coefficient, a in metres

Figure A.2 — Presentation of results

Annex B (informative)

Thermal transmittance through dampers and valves

B.1 Introduction

In a ducted system where there is a significant difference in air temperature between two sides of a closed damper or valve, it is sometimes important to establish thermal loss through the damper due to combination of air leakage and thermal transmittance of the damper structure.

With a tight shut off damper the main contribution to thermal loss is the thermal transmittance of the damper structure. Thermal loss due to air leakage is related to pressure difference across the closed damper.

B.2 Scope

This annex specifies methods for the thermal testing of dampers and valves in a closed blade condition using a substitution method. The symbols used are shown in Table B.1.

B.3 Thermal loss test using a substitution method

B.3.1 Carry out the tests using the arrangements shown in Figure B.1. Test 1 measures the thermal leakage of the test chamber with the substitution wall in position; this element is of a similar construction to the test chamber itself and should be sealed into the aperture of the enclosure. Test 2 measures the thermal leakage of the test chamber with the damper in place of the wall. The damper should be in the fully closed position, and the size of the damper should be 1 m × 1 m or the nearest largest size.

B.3.2 Connect a fan to the chamber to provide an overpressure to the chamber, with the motor of the fan outside the chamber and not in the airstream. The chamber should contain an electric heat source to heat the internal air. The dimensions of the test chamber should be as close as practicable to 1,2 m x 1,2 m x 1,2 m and the walls of well insulated construction (thermal transmittance $0,5 \text{ W}\cdot\text{m}^{-2}\cdot\text{K}^{-1}$).

B.3.3 Set the fan to provide an overpressure of 50 Pa and adjust the heater to give an internal air temperature at least 30 K higher than the ambient external temperature. When measuring the chamber temperature, care should be taken to avoid the effects of radiation from the electric resistance.

B.3.4 Test 1

When temperatures inside and outside the enclosure are constant, measure the thermal heat flow leaking through the walls of the chamber with the substitution wall. Calculate the thermal transmittance (U_c) of the test chamber as follows, and give details of the calculation in the measurement report.

Thermal transmittance of the test chamber, $U_c = \frac{\dot{Q}_1}{\Delta\theta_1 \cdot A_{tot}}$

Table B.1 —Symbols used for thermal transmittance test

Symbol	Quantity	Unit
A_{tot}	Total wall area of the chamber and substitution wall	m ²
A_d	Area of the damper under test	m ²
$\Delta\theta_1$	Temperature difference in test 1	K
\varnothing_1	Power of the heating resistance in test 1	W
\varnothing_2	Power of the heating resistance in test 2	W
A_1	Area of the substitution wall	m ²
$\Delta\theta_2$	Temperature difference in test 2	K
\varnothing_d	Thermal leakage of the damper	W
U_d	Thermal transmittance of the damper or valve	W·m ⁻² ·K ⁻¹
U_c	Thermal transmittance of the test chamber	W·m ⁻² ·K ⁻¹
Δp_o	Overpressure in chamber	Pa

B.3.5 Test 2

Replace the substitution wall with the damper under test and repeat B.3.2 and B.3.3.

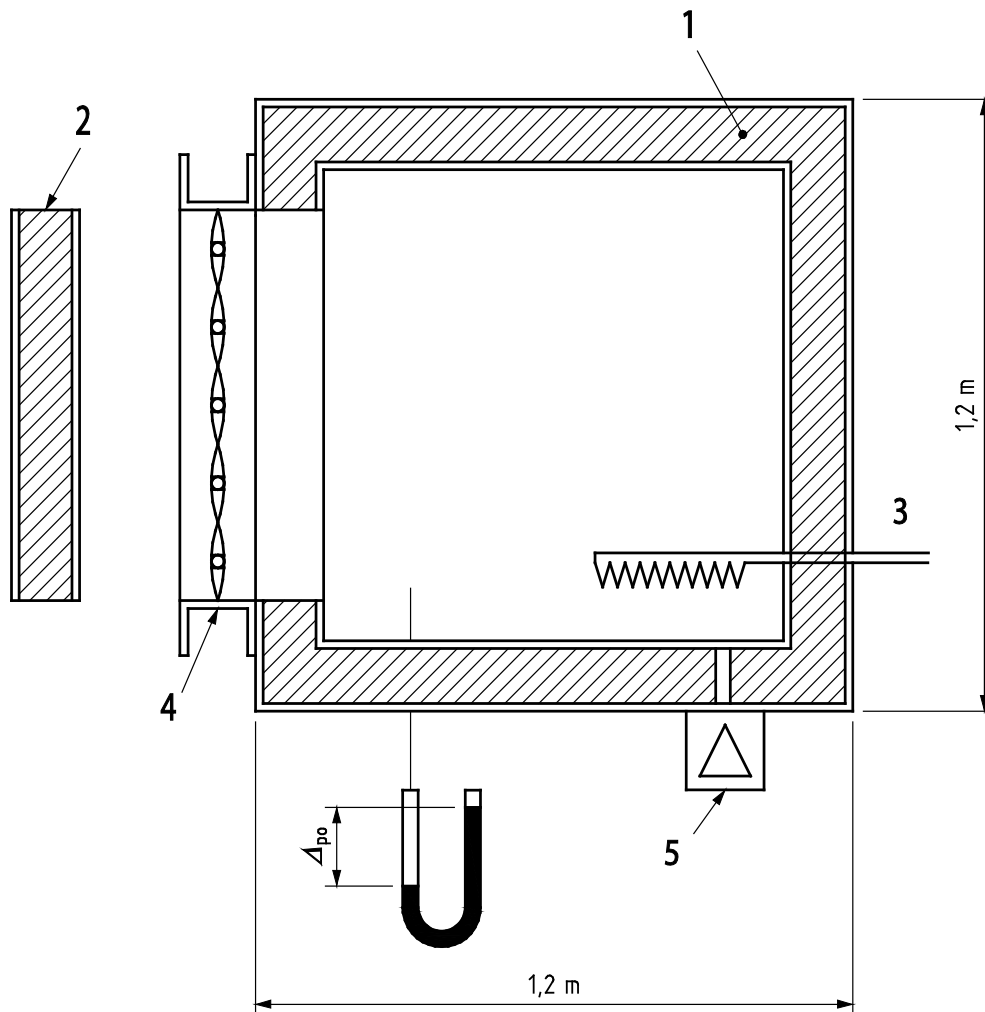
B.3.6 When temperatures inside and outside the enclosure are constant, measure the heat flow leaking through the walls of the chamber and damper (\varnothing_2). Determine the thermal transmittance of the damper or valve as follows:

Thermal leakage of the damper
$$\varnothing_d = \varnothing_2 - U_c (A_{tot} - A_1) \Delta\theta_2$$

Thermal transmittance of the damper
$$U_d = \frac{\varnothing_d}{A_d \cdot \Delta\theta_2}$$

B.3.7 Report the test results as thermal transmittance for an over pressure of 50 Pa.

B.3.8 The test report should include an estimation of measurement and calculation error.



Key

- 1 enclosure/chamber
- 2 substitution wall
- 3 heating resistance
- 4 test damper or valve
- 5 pressurization fan

NOTE Figure B.1 shows two options that are:

- Test 1 with substitution wall (Key 2) mounted on chamber,
- Test 2 with test damper or valve (Key 4) mounted on chamber.

Figure B.1 — Measuring arrangement for thermal transmittance

Annex C (normative)

Classification of a damper or valve leakage

C.1 Scope

This annex specifies a method of classifying the leakage from a closed damper or valve and the leakage from a damper or valve casing.

C.2 Leakage through closed blade(s)

The range of leakage performance has been divided into classes 0, 1, 2, 3 and 4:

Class 0 No control on leakage applicable, for example, to volume control dampers which do not have to provide a shut-off capability;

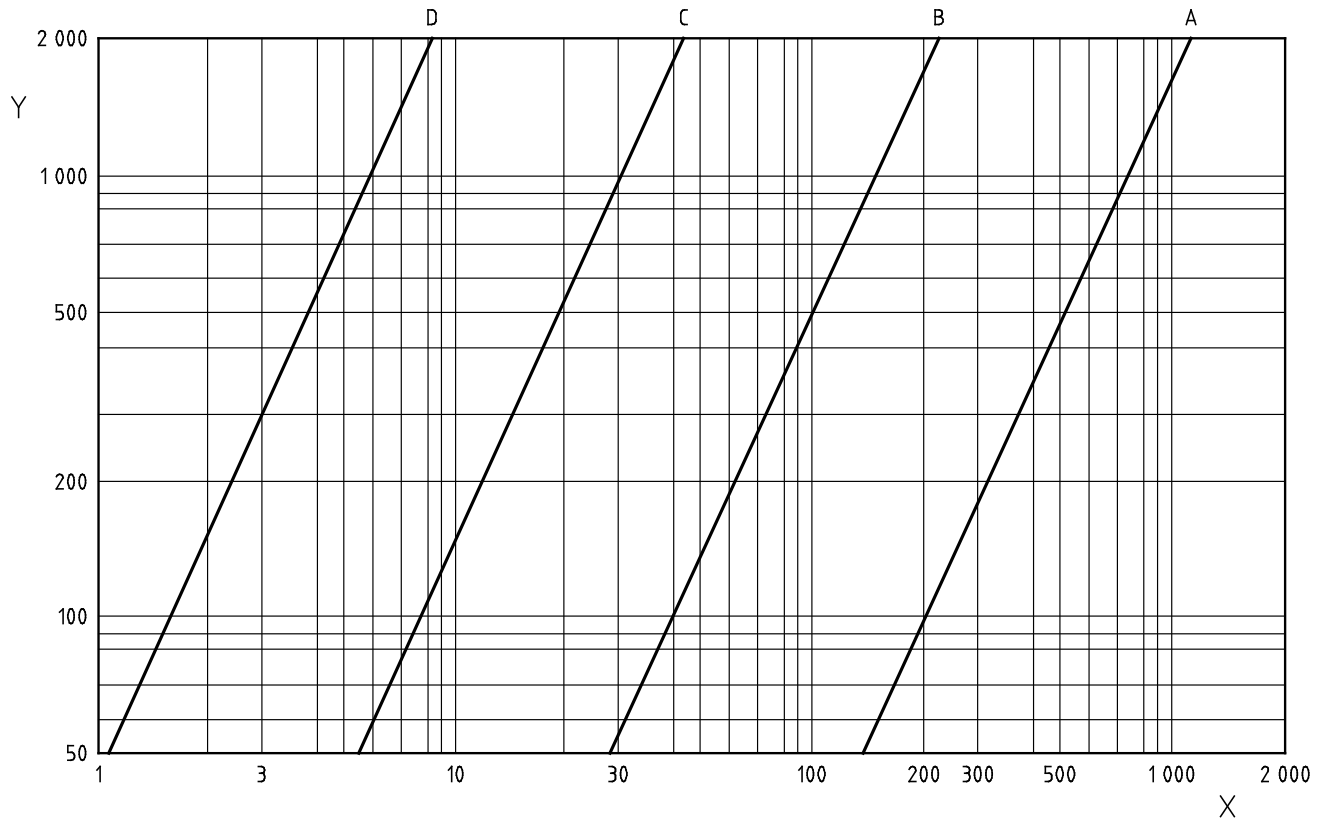
Classes 1, 2, 3, 4 See Figure C.1 for permitted maximum air leakage factor q_{VLBA} in $\text{l}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ across closed blades as a function of duct static pressure p_s in Pa.

C.3 Casing leakage

The range of case leakage performance is related to the general ductwork leakage classes as follows:

The reference casing area is taken as the perimeter of the damper multiplied by an equivalent length of 1 m.

Figure C.2 gives for classes A, B and C the permitted maximum case air leakage factor q_{VLCA} in $\text{l}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ as a function of duct static pressure p_s in Pa.

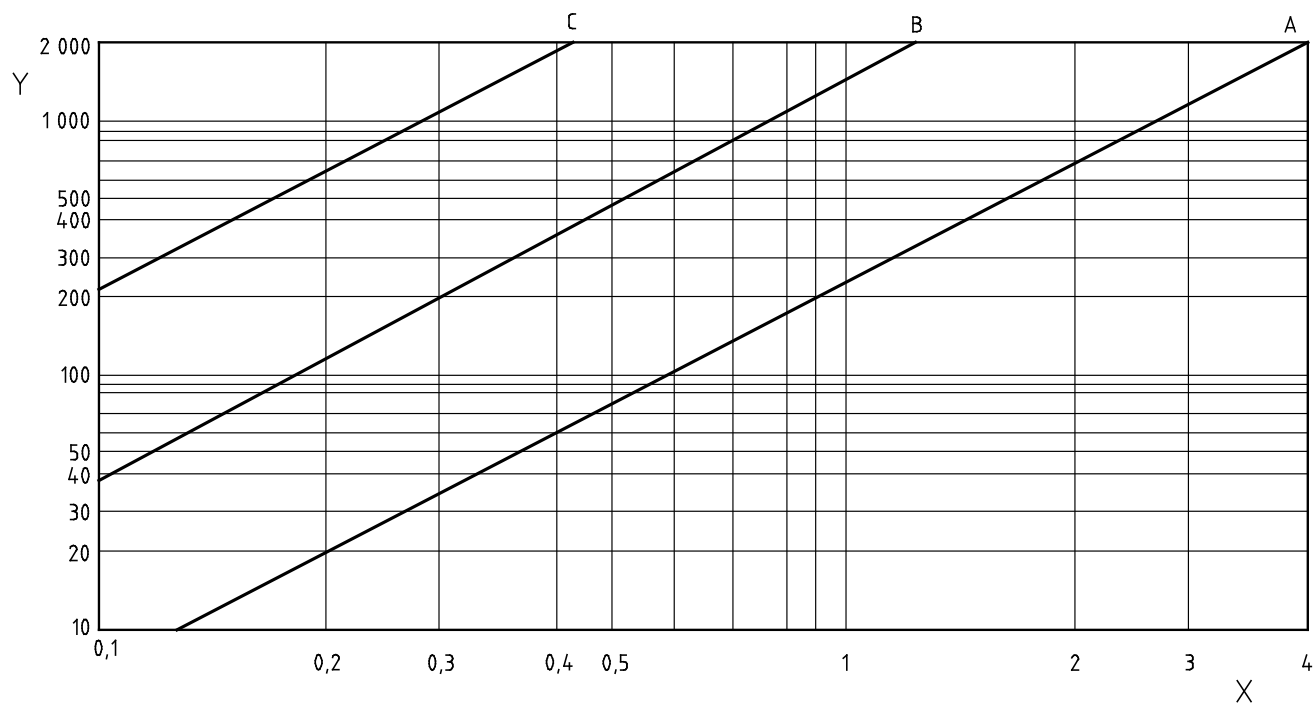


Key

Class 0: no control on leakage

- A Class 1
- B Class 2
- C Class 3
- D Class 4
- X air leakage factor q_{vLBA} $l/(s \cdot m^2)$
- Y duct pressure p_s in Pa

Figure C.1 — Classification of closed blade leakage



Key

- A Class A
- B Class B
- C Class C
- X air leakage factor q_{vLCA} l/(s·m²)
- Y duct pressure p_s in Pa

Figure C.2 — Classification of case leakage

Annex D (informative)

Effect of Duct Configuration on Pressure Loss Coefficient

D.1 General

Depending on the connecting duct configuration (see Figure D.1) the measured pressure drop can vary.

The tests described in 6.1 are based on a fully ducted damper (configuration A).

The tests described in 6.2 using the chamber method can be related to configuration D.

Table D.1 gives very approximate guidance on correction factors to estimate the pressure loss coefficient depending on the ducting configuration. The fully ducted configuration (A, on Figure D.1) is taken as the reference .

Precise values of these correction factors depend on an actual damper internal construction, blade profile, blade linkage and blade coupling (opposed or parallel) as these have effects on the local aerodynamics as the air passes through the damper.

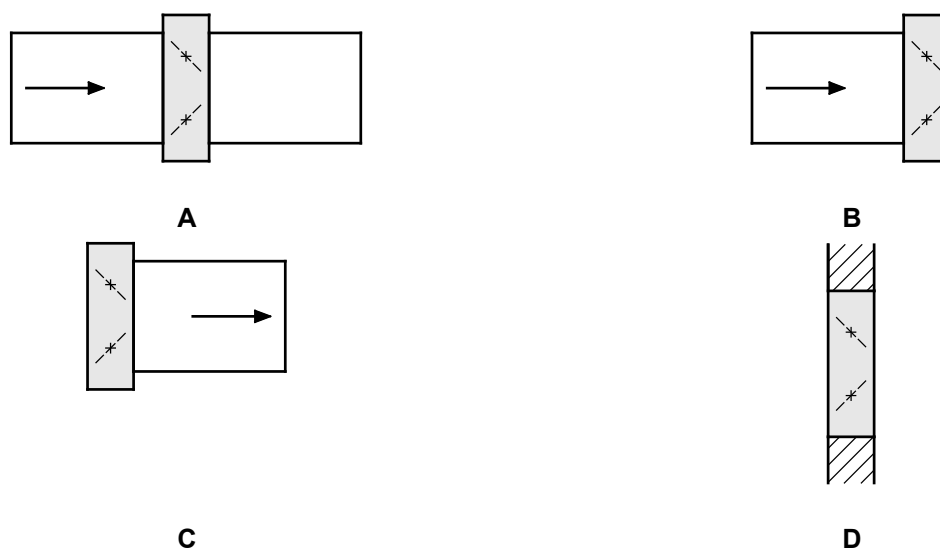


Figure D.1 — Possible duct connections to a damper

Table D.1 —Correction factors to pressure loss coefficient

<u>Type of Duct Configuration.</u>	<u>Type of operation</u>	<u>Correction factors F</u> <u>Where blade $\alpha =$</u>								
		0 ^{oa}	10 ^{oa}	20°	30°	40°	50°	60°	70°	80°
<u>B</u>	opposed	6	5,5	3,0	2,0	1,5	1,3	1,2	1,1	1,0
	parallel	12	10,0	3,5	2,0	1,5	1,3	1,2	1,1	1,0
<u>C</u>	opposed	4	3,5	2,3	1,7	1,4	1,3	1,2	1,1	1,0
	parallel	7	6,0	2,2	1,6	1,5	1,3	1,2	1,1	1,0
<u>D</u>	opposed	10	8,0	4,5	2,7	1,9	1,7	1,5	1,2	1,0
	parallel	19	15,0	5,0	2,4	1,9	1,7	1,5	1,2	1,0

^a As pressure drop in reference configuration A is relatively small the accuracy of factor F can be very poor.

D.2 Application of correction factor

As an example, pressure drop was measured in configuration A at a blade angle of 10° .

Require to estimate pressure loss coefficient for configuration C.

$$\text{At } \alpha = 10^\circ \quad \xi_C = F \cdot \xi_A$$

$$\text{Configuration C at } \alpha = 10^\circ \quad \Delta p_t = 0,5 \cdot F \cdot \xi_A \cdot \rho \cdot v^2$$

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- [1] EN 15727, *Ventilation for buildings - Ducts and ductwork components, leakage classification and testing*
- [2] ISO 3966, *Measurement of fluid flow in closed conduits - Velocity area method using Pitot static tubes*

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