BRITISH STANDARD

BS EN 12589:2001

Ventilation for buildings — Air terminal units — Aerodynamic testing and rating of constant and variable rate terminal units

The European Standard EN 12589:2001 has the status of a British Standard

ICS 91.140.30

National foreword

This British Standard is the official English language version of EN 12589:2001.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Air distribution and air diffusion, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 16 November 2001

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EUROPEAN STANDARD

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EN 12589

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English version

Ventilation for buildings — Air terminal units — Aerodynamic testing and rating of constant and variable rate terminal units

Ventilation des bâtiments — Unités terminales — Essais aérodynamiques et évaluation des unités terminales à débit constant et variable

Lüftung von Gebäuden — Luftdurchlasseinheiten — Aerodynamische Prüfung und Bewertung von Luftdurchlasseinheiten mit konstantem und variablem Luftvolumenstrom

This European Standard was approved by CEN on 18 August 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Contents

Foreword

This European Standard 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 March 2002, and conflicting national standards shall be withdrawn at the latest by March 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies methods for the aerodynamic testing and rating of constant and variable flow rate terminal units suitable for use with air distribution systems.

The terminal units considered are:

- — single and dual duct;
- — induction;
- — fan assisted induction (parallel and series);
- — single duct with integral diffuser.

The tests for each type of unit are summarized in Figure 1.

The tests in this standard are designed to determine fully the aerodynamic performance of terminal units and provide a basis for the comparison of the suitability of such assemblies when correctly installed in an air distribution system.

2 Normative references

This European Standard incorporated by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references the subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

CR 12792, *Ventilation for buildings — Symbols, units and terminology.*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices — Part 1: Orifice plates, nozzles and venturic tubes inserted in circular cross-section conduits running full.*

ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes.*

ISO 5221, *Air distribution and air diffusion — Rules to methods of measuring air flow rate in an air handling duct.*

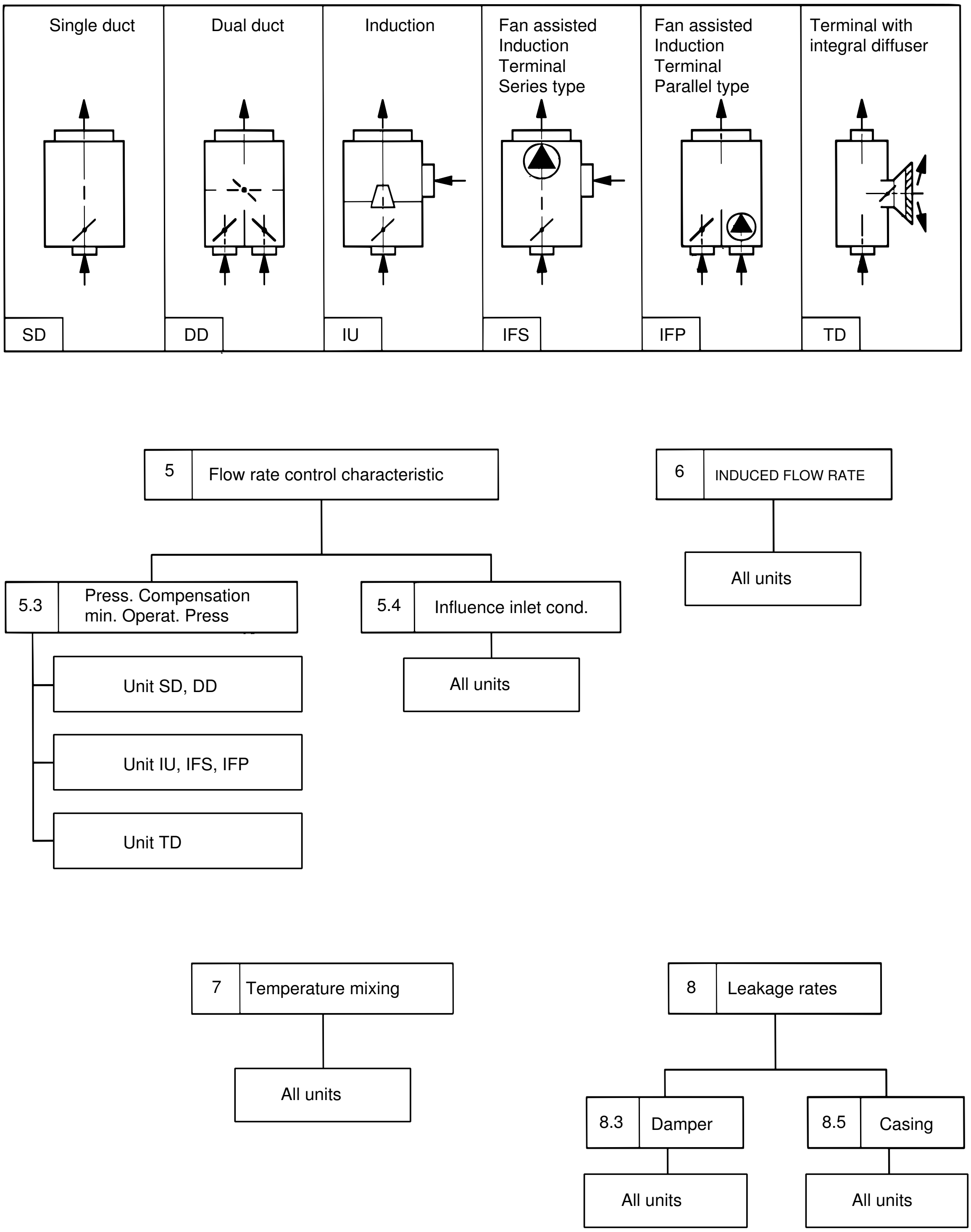


Figure 1 — Test units and test requirements

3 Terms, definitions and symbols

3.1 For the purposes of this standard, the terms and definitions given in CR 12792 apply.

3.2 The symbols and the suffixes used in this standard are shown in Tables 1 and 2 respectively.

Table 1 — Symbols used for testing air terminal units

Symbol	Quantity	Units
A_c	Internal cross-sectional area of duct	m^2
d_e	Equivalent diameter $\sqrt{4A_c/\pi}$	m
p	Absolute static pressure	Pa
p_a	Atmospheric pressure	Pa
p_d	Velocity pressure	Pa
p_r	Stagnation (or absolute total pressure)	Pa
p_s	Static gauge pressure ($p - p_a$)	Pa
p_t	Total pressure ($p_r - p_a$)	Pa
Δp	Flow meter pressure difference	Pa
Δp_t	Total pressure difference	Pa
q_v	Volume rate of air flow at the flow meter	$m^3.s^{-1}$ *or* $l.s^{-1}$
q_{vL}	Leakage volume rate of air flow	$m^3.s^{-1}$ *or* $l.s^{-1}$
Q_{vLBA}	Leakage volume rate of air flow across a valve per unit cross-sectional area	$m^3.s^{-1}.m^{-2}$ or $l.s^{-1}.m^{-2}$
Q_{vLCA}	Leakage volume rate of air flow through casing per unit cross-sectional area	$m^3.s^{-1}.m^{-2}$ or $l.s^{-1}.m^{-2}$
v	Velocity	$m.s^{-1}$
ρ	Air density	$kg.m^{-3}$
θ	Celsius temperature	°C
S	Position of valve or induction damper setting	% or α
n	Fan speed control setting	V or position

Table 2 — Suffixes used with the symbols in Table 1

0	recommended value (usually by the manufacturer)
1	inlet of the unit under test
2	outlet of the unit under test
3	induction port(s) of the unit under test
i	outlet air temperature
c	cold side of the unit under test
w	warm side of the unit under test
u	measuring point upstream of the flow meter
D	measuring point upstream of the discharge flow meter
sn	nett surface area of the unit under test
ca	casing of the unit under test
va	valve of the unit under test

4 Instrumentation

4.1 Air flow rate measurement

4.1.1 The air flow rate shall be measured using instruments in accordance with ISO 5167-1.

4.1.2 Air flow meters shall have the ranges and accuracies shown in Table 3.

Table 3 — Ranges and accuracies of air flow meters

Range $m^3 \cdot s^{-1}$	**Measurement error** %
> 0,007 ≤ 0,07	± 5
> 0,07 ≤ 7,00	± 2,5

NOTE Flow meters may be calibrated *in situ* by means of pitot static tube traverse techniques described in ISO 3966.

4.1.3 Leakage air flow meters shall have the ranges and accuracies shown in Table 4.

Table 4 — Ranges and accuracies of leakage air flow meters

Range $m^3 \cdot s^{-1}$	**Measurement error** %
≤ 0,018	$0,9 \times 10^{-3}$ $m^3.s^{-1}$
> 0.018	± 5 %

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

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

a) a dimensional check for all flow meters not requiring calibration;

b) a check calibration over their full range using the original method employed for initial calibration or meters calibrated *in situ*;

c) a check against a flow meter which meets the flow meter specification in accordance with ISO 5221.

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 maximum scale or display interval shall not be greater than the characteristics listed for the accompanying range of manometers, shown in Table 5.

Table 5 — Maximum scale or display interval

Range Pa	**Maximum scale interval** Pa
≤ 25	1,0
> 25 to 250	2,5
> 250 to 500	5,0
> 500	25,0

4.2.3 For air flow rate measurements, the minimum pressure differential shall be:

a) 25 Pa with an inclined tube manometer or micro-manometer;

b) 500 Pa with a vertical tube manometer.

4.2.4 The calibration standards shall be:

a) for instruments with the range up to 25 Pa, a micro-manometer accurate to ±0,5 Pa;

b) for instruments with the range of 25 Pa to 500 Pa, a manometer accurate to ±2,6 Pa (hook gauge or micro-manometer);

c) for instruments with the range of 500 Pa and upwards, a manometer accurate to ±25 Pa (vertical manometer).

4.3 Temperature measurement

Measurement of temperature shall be by means of mercury-in-glass thermometers, resistance thermometers or thermo-couples. Instruments shall be graduated to give readings in intervals not greater than 0,5 K and calibrated to an accuracy of ±0,25 K.

5 Tests for flow rate control characteristics

5.1 Principle

To determine the changes in primary air flow rate resulting either from variations in the pressure differential between the inlet duct(s) and the outlet duct(s) or chamber or upstream pressure whichever is appropriate.

Also, to determine the pressure differential between upstream and downstream of the terminal unit, and additionally the minimum pressure difference which is necessary to reach the performance of the terminal unit within the specified operating tolerances (minimum operating pressure difference).

5.2 Test measurements

The following parameters shall be measured during the tests:

a) p_{s1} inlet duct static gauge pressure.

b) p_{s2} static gauge pressure in the chamber into which the outlet duct discharges (p_{s2} = 0 if free outlet conditions are used).

c) θ_1 air temperature at the inlet to the unit under test.

d) Δp the flow meter pressure difference (or the appropriate parameter that relates to the air flow q_{v1}).

e) p_{su} the static gauge pressure immediately upstream of the flow meter.

f) θ_u the air temperature immediately upstream of the flow meter.

g) p_a the atmospheric pressure at the beginning and end of the tests.

5.3 Pressure compensation and minimum operating pressure difference(Δp_{tmin})

5.3.1 Units without induction SD, DD

NOTE This test is required for pressure independent units only.

5.3.1.1 Test installation

A typical test installation for type SD units is shown in Figure 2.

Performance of static pressure measurement device is described in annex A.

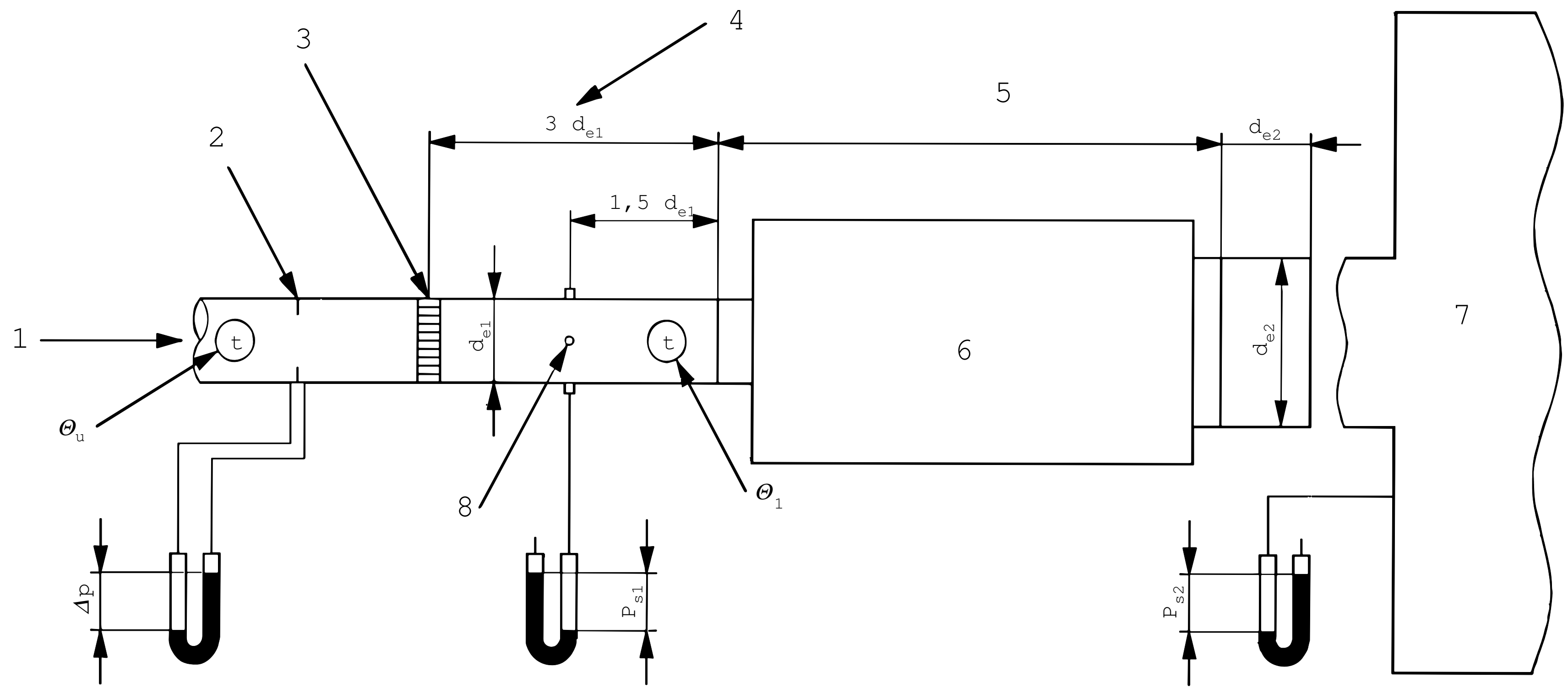
A typical test installation for type DD units is shown in Figure 3. All the test equipment described in clause 4 should be installed for both supply ducts. Discharge temperature measurement equipment should be installed if mixing efficiency is to be determined.

5.3.1.2 Test procedure

5.3.1.2.1 With the supply fan running, set the flow rate controller to its maximum setting. Increase the pressure differential between the inlet(s) and the outlet(s) to the manufacturers recommended maximum operating pressure differential and record the test measurements in accordance with 5.2.

5.3.1.2.2 Decrease the pressure differential in stages, approximately to the values given in Table 6 until the flow rate has reached a value equal to or less than 50 % of the value obtained in the pressure differential range where the flow rate is seen to be approximately constant. At each stage record the test measurements in accordance with 5.2.

When making the adjustments to pressure, if the pressure falls below the next prescribed value, increase it to the value at the start of the test, and then slowly decrease it to the specified value before a further measurement is taken.



Key

1 Air flow

2 Flow rate measuring device which conforms to ISO 5167-1

3 Flow straightener which conforms to ISO 5167-1

4 This length to be straight and its cross section uniform and equal to that of the inlet spigot

5 Total length of unit

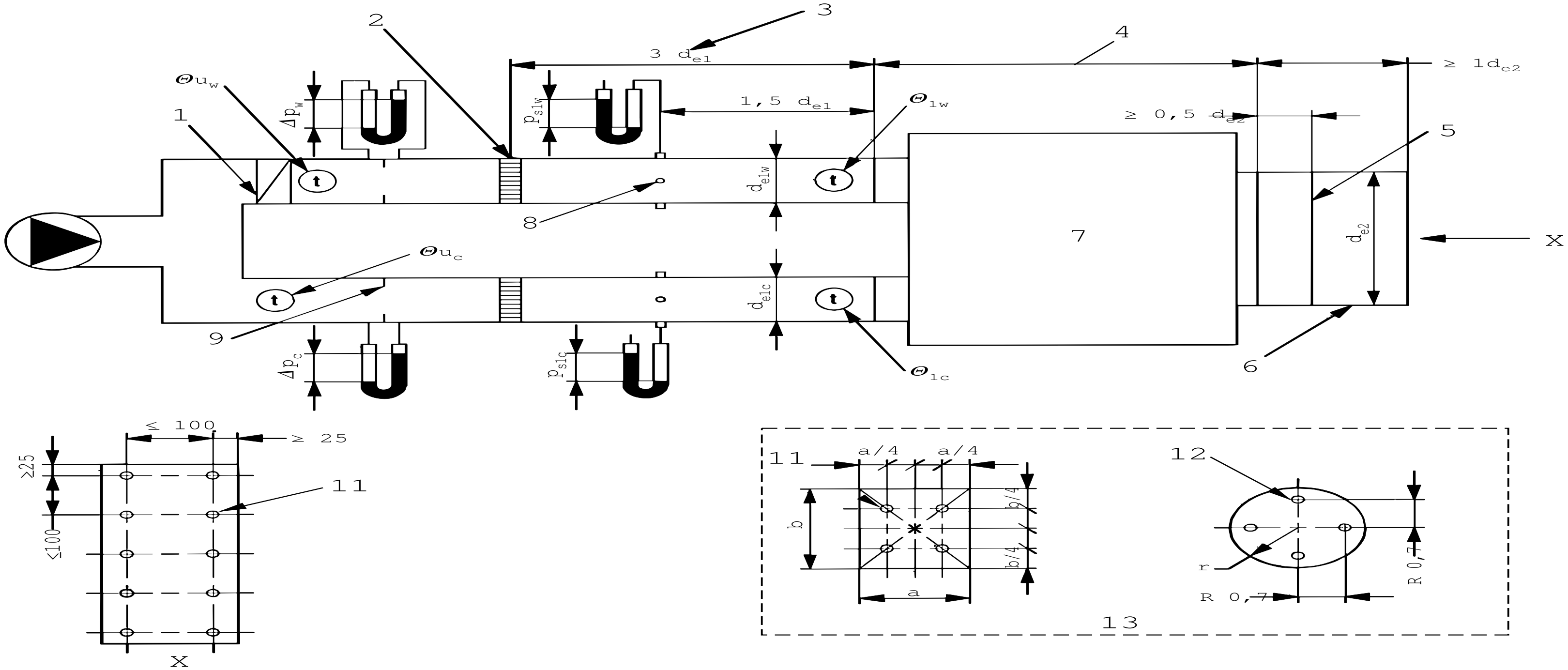
6 Unit under test

7 Chamber such as reverberation room

8 Peizometric ring

NOTE Dual duct unit: Each duct to be measured seperately

Figure 2 — Typical test installation to determine flow rate control characteristics for units SD; DD and damper leakage characteristics for all units



Key

1 Heat exchanger

2 Flow straughtener which conforms to ISO 5167-1

3 This length to be straight and its cross section uniform and equal to that of the inlet spigot

4 Total length of unit

5 Total length of unit

6 Outlet duct internal dimensions equal to those of unit outlet

7 Unit under test

8 Piezometric ring

9 Flow rate measuring device which conforms to ISO 5167-1

10 Points of measurement in outlet duct

11 Temperature stations in rectangular duct

12 Temperature stations in circular duc

13 Points of measurement in inlet duct(s) or outlet duct(s) extension of multiple outlet unit

Figure 3 — Typical installation to determine temperature mixing efficiency DD; IU; IFS; IFP

5.3.1.2.3 Reduce the pressure differential to zero, and then restore it the level at which the last measurement was made. Increase the pressure differential in stages approximately to the values given in Table 6 until the maximum pressure differential is reached. At each stage record the test measurements in accordance with 5.2.

When making the adjustments to pressure, if the pressure rises above the next specified value, reduce it to zero and then slowly increase it to the specified value before a further measurement is taken.

Table 6 — Pressure differentials (values in R10 series)

2 000; 1 600; 1 250; 1 000; 800; 630; 500; 400; 315; 250; 200; 125; 63; in Pa

5.3.1.2.4 Repeat procedures 5.3.1.2.2 and 5.3.1.2.3 for flow rates at mid-range and minimum settings as typically shown in Figure 4.

5.3.1.2.5 Dual duct units with mixing dampers and separate air flow rate controller: repeat procedures 5.3.1.2.2 and 5.3.1.2.3 for mixing valve settings at approximately 100 %; 75 %; 25 % and 0 %. In the case of a VAV-dual duct unit, repeat this procedure for the maximum and minimum flow rate setting.

For dual ducts, with air flow rate controllers for each supply duct, see 5.3.1.2.4.

5.3.2 Units with induction IU, IFS, IFP

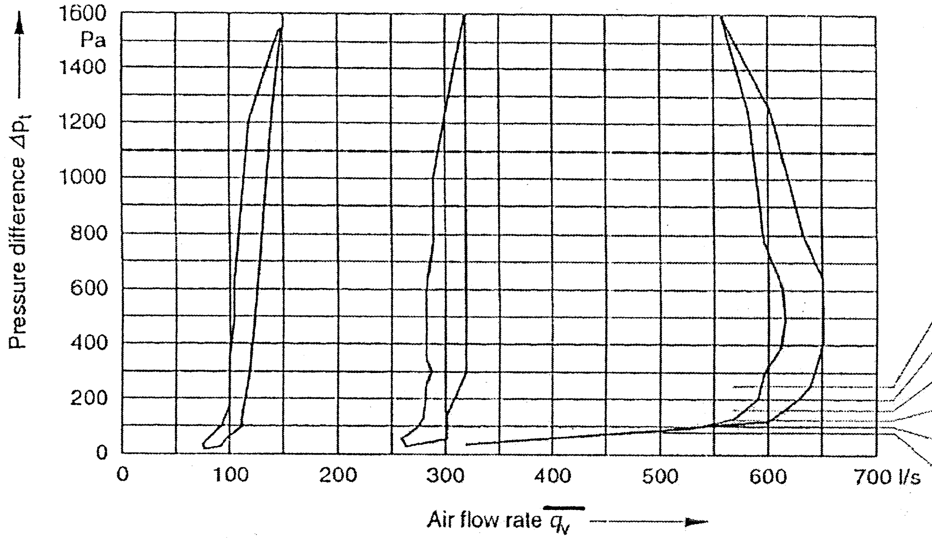
NOTE This test is required for pressure independent units only.

5.3.2.1 Test installation

A typical test installation is shown in Figure 5. Performance of static pressure measurement device is described in annex A.

5.3.2.2 Test procedure

5.3.2.2.1 The parameters applicable for each type of unit to be tested are shown in Table 7.



Δp min.	In range Δp min. 1600 Pa		$\overline{q_v}$	$\pm \overline{\Delta q_v}$ %
	$\overline{q_{v\ min.}}$	$\overline{q_{v\ max.}}$		
250	560	650	605	7,4
200	560	650	605	7,4
160	560	650	605	7,4
125	560	650	605	7,4
100	530	650	590	10,2
80	470	650	560	16,1

Figure 4a) – Example of pressure compensation

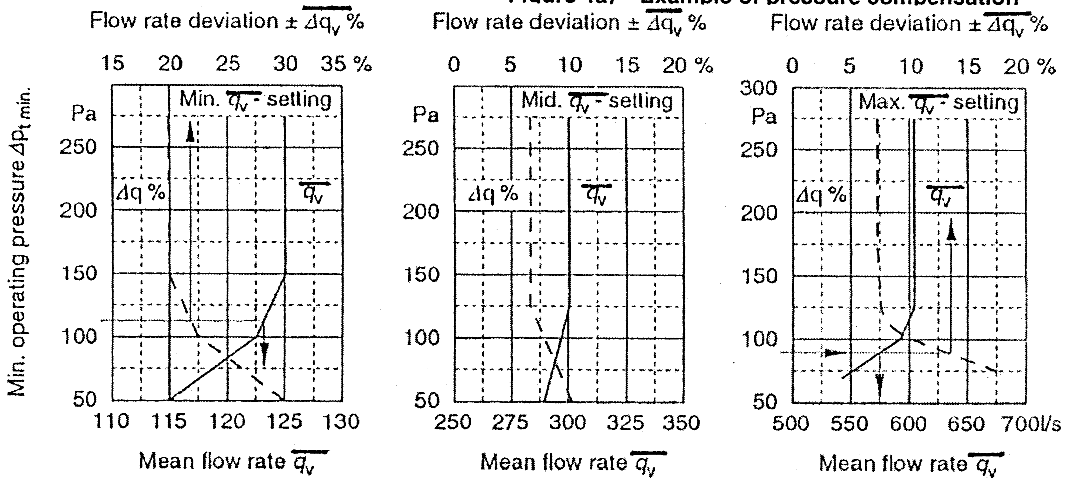
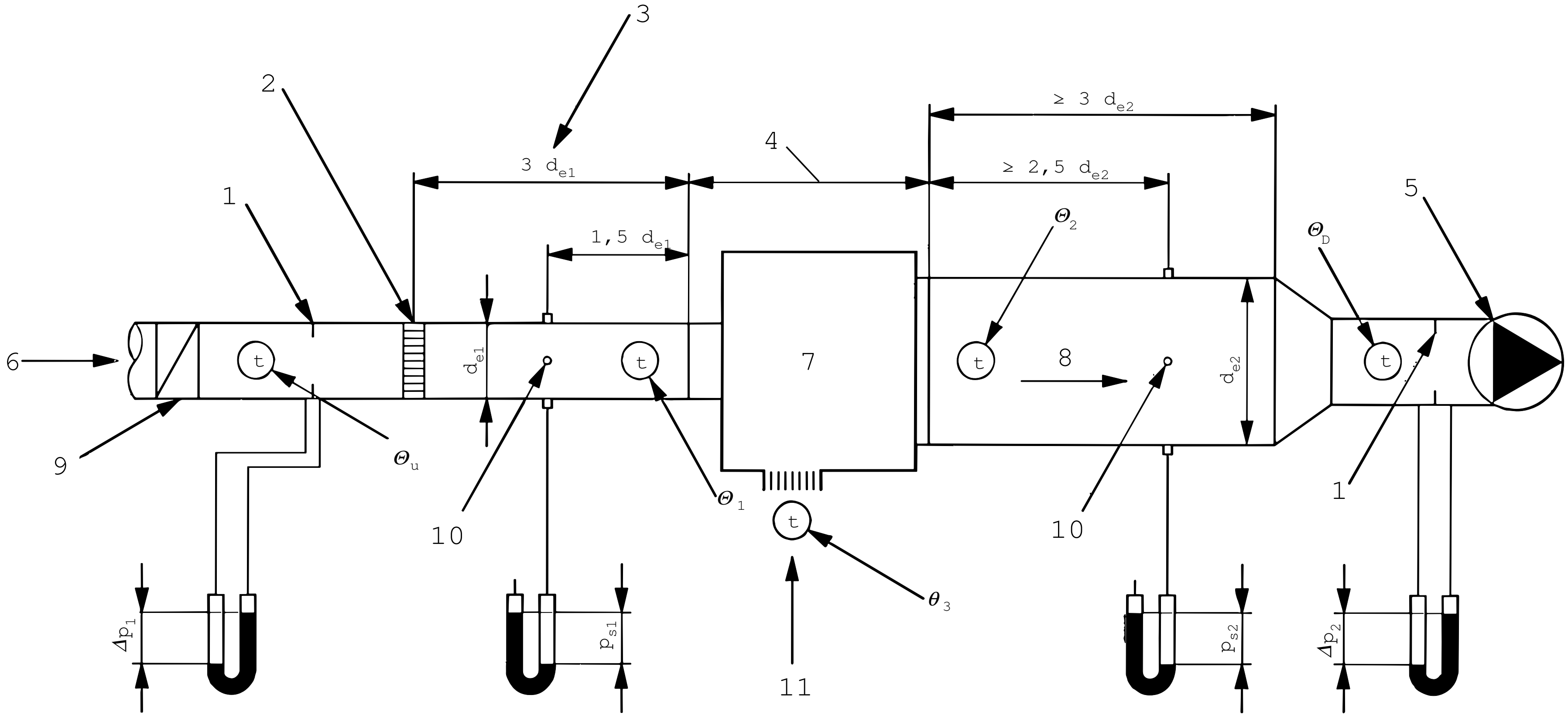


Figure 4b) — Example of determination of mean air flow rate and flow rate deviation as function of various minimum operating pressures



Key

1 Flow rate measuring device which conforms to ISO 5167-1
8 Total air flow
3 This length to be straight and its cross section uniform and equal to that of the inlet spigot
4 Total length of unit
5 Auxiliary fan
6 Air flow
7 Unit under test
8 Total air flow
9 Heat exchanger
10 Piezometric ring
11 Induced air flow

NOTE See Figure 3 for positions of temperature measurement stations

Figure 5 — Typical installation with induced air flow, using an auxiliary fan. Types IU; IFS; IFP

Table 7 — Conditions for testing induction IU, IFS and IFP units

Unit type	Induction inlet	Auxiliary fan status [a]	Units fan	Measurement
IU	sealed	on or off	—	$q_v = f(p_{s2} - p_{s1})$
IFP	sealed	on or off	off	$q_v = f(p_{s2} - p_{s1})$
IFS	open	on, and adjust together with unit fan to provide maximum prim. air flow rate in discharge duct with $Ps2$ - 50 Pa	on	$q_v = f(p_{s1})$
[a] See Figure 5.				

With the supply fan running, set the flow controller to its maximum setting. Increase the pressure differential between the inlet and the outlet or the upstream pressure to the manufacturer's recommended maximum operating pressure differential, and record the test measurements in accordance with 5.2.

5.3.2.2.2 Decrease the pressure differential in stages, approximately to the values given in Table 6, until the flow rate has reached a value equal to or less than 50 % of the value obtained in the pressure differential range where the flow rate is seen to be approximately constant. At each stage record the test measurements in accordance with 5.2.

When making the adjustments to pressure, if the pressure falls below the next specified value, increase it to the value at the start of the test, and then slowly reduce it to the specified value before a further measurement is taken.

5.3.2.2.3 Calculate the flow rate at unit under test according to formula (1).

5.3.2.2.4 Repeat procedures 5.3.2.2.2 and 5.3.2.2.3 for flow rates at mid-range and minimum settings as typically shown in Figure 4.

5.3.3 Units with integral diffuser and outlet damper, TD

NOTE This test is required for pressure independent units only.

5.3.3.1 Test installation

A typical test installation is shown in Figure 6.

Performance of static pressure measurement device is described in annex A.

5.3.3.2 Test procedure

5.3.3.2.1 Calculate $q_{v0} = v_0 \times A_0$, where v_0 is the manufacturer's maximum recommended velocity.

With the supply fan running, set the auxiliary constant flow rate controller $q_{v2} = q_{v0} - q_{v1}$, where q_{v1} is the maximum recommended flow rate of unit under test.

Set the flow rate controller of unit under test to its maximum setting. Increase the pressure differential between the inlet and the outlet to the manufacturer's recommended maximum operating pressure differential, and record the test measurements in accordance with 5.2.

5.3.3.2.2 Decrease the pressure differential in stages, approximately to the values given in Table 6, until the flow rate has reached a value equal to or less than 50 % of the value obtained in the pressure differential range, where the flow rate is seen to be approximately constant. At each stage record the test measurements in accordance with 5.2.

Calculate the flow rate of unit under test as

$$q_{v1} = q_{v0} - q_{v2} \quad (1)$$

When making the adjustments to pressure, if the pressure falls below the next specified value, increase it to the value at the start of the test and then slowly reduce it to the specified value before a further measurement is taken.

5.3.3.2.3 Reduce the pressure differential to zero, and then restore it to the level at which the last measurement was made. Increase the pressure differential in stages, approximately to the values given in Table 6, until the maximum pressure differential is reached. At each stage record the test measurements in accordance with 5.2.

Calculate the flow rate at unit under test according to formula (1).

When making the adjustments to pressure, if the pressure rises above the next specified value, reduce it to zero, and then slowly increase it to the specified value before a further measurement is taken.

5.3.3.2.4 Repeat procedures 5.3.3.2.2 and 5.3.3.2.3 for flow rates of unit under test at mid-range and minimum settings as typically shown in Figure 4.

5.3.3.2.5 Repeat the test procedure as specified in 5.3.3.2 with the auxiliary constant flow rate controller setting of half of the manufacturer's recommended maximum velocity.

$$q_{v0} = q_{v2} - q_{v1} \quad (2)$$

5.3.3.2.6 Repeat the test procedure as specified in 5.3.3.2 with the auxiliary flow rate controller discharge sealed (q_{v2} = 0).

5.4 Influence of 90° radiused bend

5.4.1 Principle

Non uniform flow conditions in the inlet duct to the unit can influence the flow rate control characteristics. This section deals with the evaluation of an upstream 90° bend. If appropriate other non-straight duct configurations can be dealt with in a similar way.

5.4.2 Test measurements

5.4.2.1 General

Test measurements shall be made in accordance with 5.2.

5.4.2.2 All units

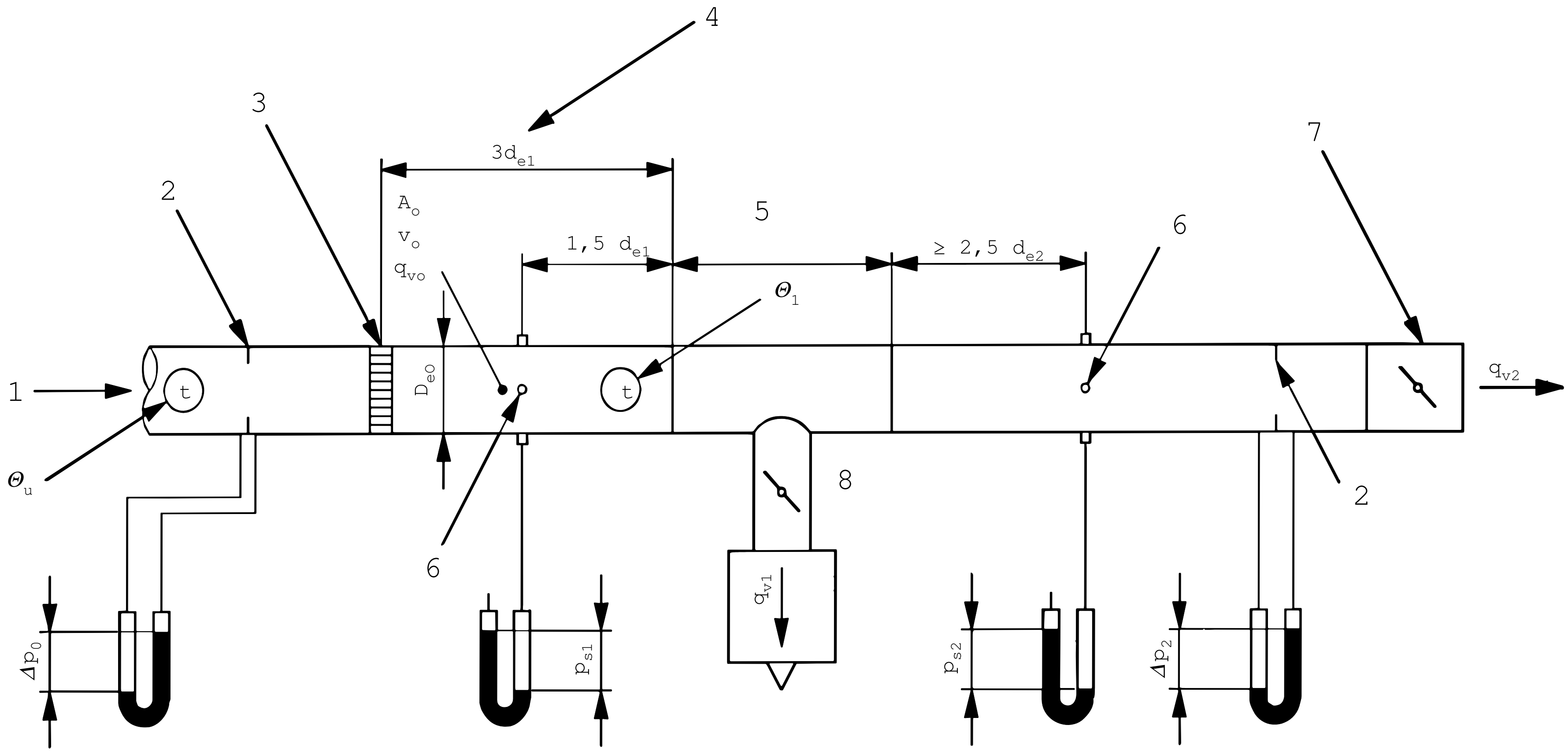
5.4.2.2.1 Test installation

A typical test installation is shown in Figure 7.

The test shall be conducted with the supply duct in both the horizontal and vertical axis.

5.4.2.2.2 Test procedure

Repeat the tests as specified in 5.3.



Key

1 Air flow

2 Flow rate measuring device which conforms to ISO 5167-1

3 Flow straughtener which conforms to ISO 5167-1

4 This length to be straight and its cross section uniform and equal to that of the inlet spigot

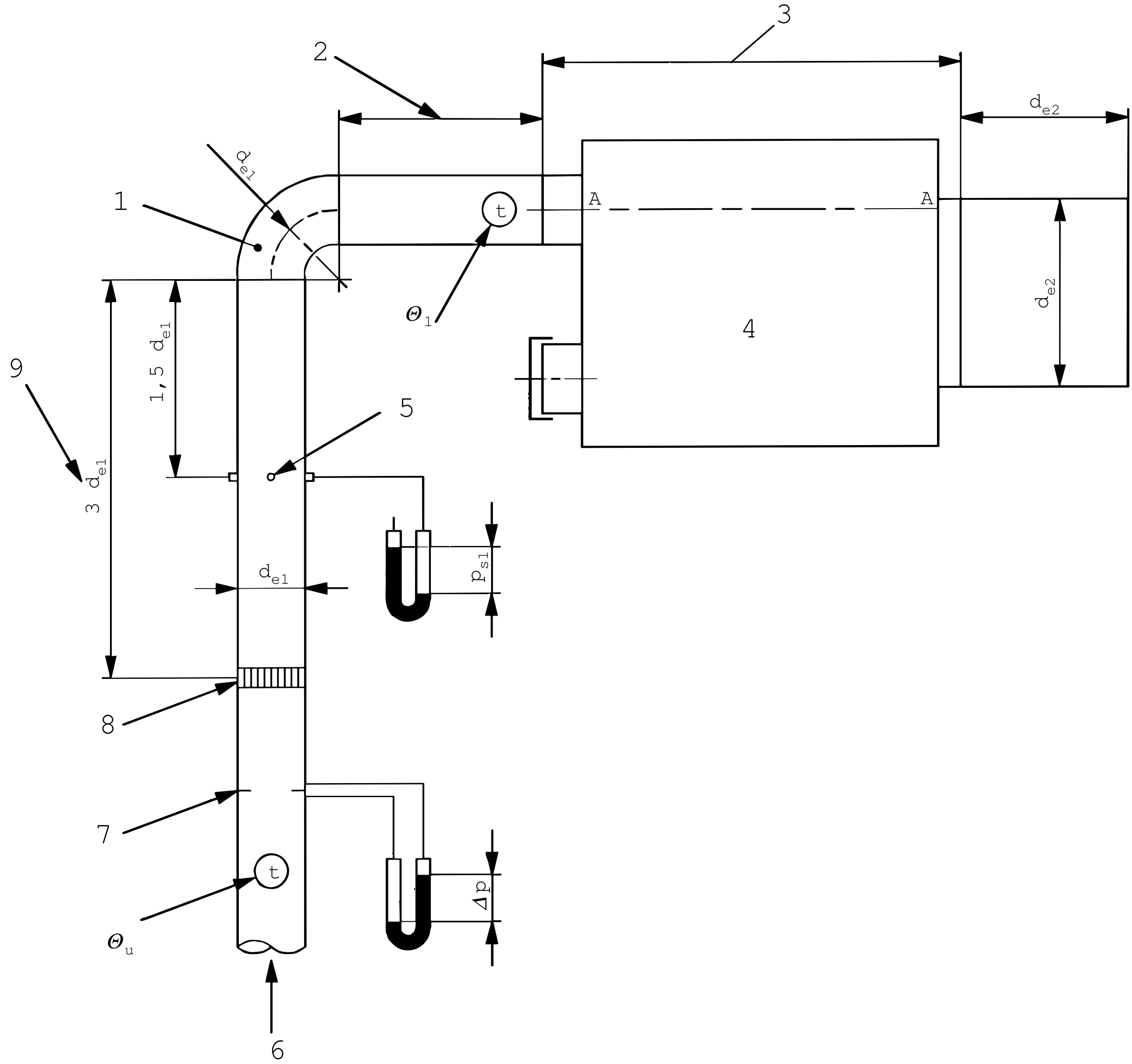
5 Total length of unit

6 Piezometric ring

7 Auxiliary constant flow rate controller

8 Unit under test as illustrated in Figure 1

Figure 6 — Typical installation to determine flow rate control characteristics for units with integral diffuser and outlet damper TD



Key

1 Sheet metal pressed bend

2 This length to be specified by the manufacturer

3 Total length of unit

4 Unit under test

5 Piezometric ring

6 Air flow

7 Flow rate measuring device which conforms to ISO 5167-1

8 Flow straightener which conforms to ISO 5167-1

9 This length to be straight and its cross section uniform and equal to that of the inlet spigot

NOTE 1 Dual duct unit: Each duct to be measured seperately

NOTE 2 Repeat procedure with test unit turned through 90° on axis A-A

Figure 7 — 90° radiused bend upstream condition for units SD; DD; IU; IFS; IFP

5.5 Calculation of test results

5.5.1 Correction to volume flow rate density variation

Determine the volume air flow rate at the flow meter (q_v). If there are significant differences in the air temperature and atmospheric pressure between the flow meter and the unit under test, such that the air density ratio ρ_u/ρ_1 is less than 0,98 or greater than 1,02, apply the following correction:

$$q_v = q_{v1} \times \rho_u / \rho 1 \qquad (3)$$

where

$$\rho_u = 3{,}48 \times 10^{-3} \left(\frac{Psu + Pa}{\theta_u + 273} \right) \qquad (4)$$

and

$$\rho_1 = 3{,}48 \times 10^{-3} \left(\frac{Ps1 + Pa}{\theta_1 + 273} \right) \qquad (5)$$

Otherwise, $q_{\upsilon 1}$ may be taken as equal to q_{υ}.

For standard reference conditions:

$$\Delta p_t = (p_{s_1} - p_{s_2}) + \frac{\rho_1}{2} q_{v1}^2 \left(\frac{1}{A_1^2} - \frac{1}{A_2^2} \right) \qquad (6)$$

5.5.2 Pressure compensation, minimum operating pressure ($\Delta p_{t\ min}$), mean air flow rate ($\overline{q}_v$) and deviation of air flow rate (Δq_υ %).

Draw a graph of Δp_t, against q_υ as shown in Figure 4 for each test carried out.

Determine, at each air flow rate setting for several selected pressure difference ranges, the mean air flow rate $\overline{q}_v$ and $\Delta \overline{q}_v \%$ (see example in Figure 4).

where

q_{max} is the maximum flow rate within the selected pressure difference range of Δp_{min} to Δp_{max}.

q_{min} is the minimum flow rate within the selected pressure difference range of Δp_{min} to Δp_{max}.

$$\Delta q_v = \pm 1 - \left(\frac{q_{min}}{\overline{q}_v} \right) 100 \quad \text{in} \% \qquad (7)$$

Draw a graph as shown in Figure 4b).

NOTE Figure 4 also includes an example of how the results in Figure 4a) are calculated.

5.6 Presentation of results

The results of the tests can conveniently be presented as shown in Figure 4b). Alternatively, the same parameters can be presented in tabular form.

6 Tests to determine induced air flow rate

6.1 Principle

To determine the variation of induced air flow rate with primary air flow rate and static pressures upstream and downstream of the terminal unit. Also, where appropriate, to determine the effect of change of induction nozzle configuration and, in the case of fan powered terminal units, change in fan speed. The basis of the test method is to measure primary and total air flow rates and derive the induced flow rate by differencing the two values.

6.2 Test measurements

The following measurements shall be made during the tests:

a) p_{s1} inlet duct static gauge pressure in Pa.

b) p_{s2} outlet duct static gauge pressure in Pa.

c) θ_1 air temperature at the primary air inlet to the unit under test in °C.

d) θ_2 air temperature at the discharge of the unit under test in °C.

e) θ_3 air temperature at the induction port of the unit under test in °C.

f) Δp_1 flow meter pressure difference or the appropriate parameter that relates to primary flow rate q_{v1} in Pa.

g) θ_u air temperature immediately upstream of the primary air flow meter in °C.

h) Δp_2 flow meter pressure difference or appropriate parameter that relates to total discharge flow rate q_{v2} in Pa.

i) θ_D air temperature immediately upstream of the total discharge air flow meter in °C.

j) n Fan speed control setting for IFS and IFP units.

k) S Induction damper and/or valve setting (for IU units).

6.3 Test installation

A typical test installation for all units is shown in Figure 5; it is based on using an auxiliary fan to control the outlet duct static pressure p_{s2}.

The flow rate measuring stations shall conform to ISO 5167-1.

The measurement plane of the outlet duct static pressure measurement shall conform to the following:

a) The outlet duct shall be of the same cross-section as the unit outlet spigot and a minimum of 3 equivalent diameters ($3d_{e2}$) in length.

b) The plane of measurement of p_{s2} shall be located at a minimum distance of 2,5 d_{e2} downstream of the unit outlet, or a location where a uniform static pressure distribution exists within ±10 % of the value at the measurement tapping. The criteria which gives the greatest length downstream of the unit discharge shall be used for p_{s2} measurement.

c) The transformation shall be at a minimum of 0,5 d_{e2} downstream of the p_{s2} measurement plane.

Performance of static pressure measurement device is described in annex A.

6.4 Test procedure

The parameters applicable for each type of unit to be tested are shown in Table 8.

Table 8 — Parameters affecting induced flow rate

Unit type	Parameters affecting induced flow rate
IU	p_{s1} p_{s2} q_{v1} S
IFS	p_{s2} q_{v1} n
IFP	p_{s2} q_{v1} n

Set the supply fan running and use the auxiliary fan to control the selected fixed values of outlet duct static pressure p_{s2}. Table 9 shows the combinations of parameters at which recordings should be made.

Table 9 — Test parameters

Parameter		IU	IFS & IFP
Inlet duct static pressure in Pa	p_{s1}	max., mean, min.	mean
Outlet duct static pressure in Pa	p_{s2}	25; 50; 75	25; 50; 75; 100
Primary air flow rate in %		100; 75; 50; 25	100; 75; 50; 25
Induction damper and/or valve setting	S	max.; mean, min.	—
Fan speed setting	n	—	max.; mean; min.

Where max., mean and min. are referred to, values shall be recommended by the manufacturer to cover the operational range of the parameter.

For each of the combinations of parameters in Table 9, test measurements should be made as specified in 6.2.

Test measurements should only be taken when all the parameters of Table 9 have stabilized.

6.5 Calculation of test results

Determine the volume air flow rates q_{v1} and q_{v2} at the respective flow meters. If there are significant differences in the air temperature and atmospheric pressure between the flow meter and the unit under test, such that the density ratio is less than 0,98 or greater than 1,02, apply the following correction for q_{v1}.

$$q_v = q_{v1} \times \frac{\rho_u}{\rho_l} \qquad (8)$$

where

$$\rho_u = 3{,}48 \times 10^{-3} \frac{P_{su} + P_a}{\theta_u + 273} \qquad (9)$$

and

$$\rho_1 = 3{,}48 \times 10^{-3} \frac{P_{s1} + P_a}{\theta_u + 273} \qquad (10)$$

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

Correction for q_{v2} should be carried out in the same manner as for q_{v1}.

Induced flow is determined for each combination of test parameters using corrected flow rates as follows:

$$q_{v3} = q_{v2} - q_{v1} \qquad (11)$$

6.6 Presentation of test results

For all types of terminal unit, tabulate the following for each individual test:

Inlet static pressure	p_{s1}
Outlet static pressure	p_{s2}
Primary flow rate	q_{v1}
Induced flow rate	q_{v3}
Fan speed setting	n (for IFP & IFS)
Induction damper and/or valve setting	S (for IU)

7 Test to determine temperature mixing

7.1 Principle

To determine the temperature mixing efficiency of the warm and cold air entering dual duct units and, in the case of the fan powered units or induction units, the efficiency of the primary and induced air mix.

7.2 Test measurements

The following measurements shall be made during the tests in accordance with Table 10.

a) p_{s1} inlet duct static gauge pressure in Pa

p_{s1w} warm inlet duct static pressure in Pa

p_{s1c} cold inlet duct static gauge pressure in Pa

b) p_{s2} outlet duct static gauge pressure in Pa
(p_{s2} = 0 if free outlet conditions are used)

c) θ_1 air temperature at the primary air inlet in °C
(based on four positions as defined in 7.3.6)

θ_{1w} air temperature at warm duct inlet in °C

θ_{1c} air temperature at cold duct inlet in °C

d) θ_{2i} outlet duct air temperatures at positions defined in 7.3.5 in °C

e) θ_3 air temperature at the induction port in °C

f) Δp_1 upstream flow meter pressure difference in Pa

Δp_{lw} flow meter pressure difference at warm duct inlet in Pa

Δp_{lc} flow meter pressure difference at cold duct inlet in Pa
(or the appropriate parameters that relate to the air flow rates)

g) θ_u air temperature immediately upstream of the flow meter in °C

θ_{uw} air temperature immediately upstream of the warm duct flow meter in °C

θ_{uc} air temperature immediately upstream of the cold duct flow meter in °C

h) Δp_2 discharge flow meter pressure difference
(or the appropriate parameter that relates to the air rate q_{u2}) in Pa

i) p_a atmospheric pressure shall be noted at the beginning and end of the test in Pa

j) θ_D air temperature immediately upstream of the total discharge air flow meter in °C

k) n fan speed control setting

l) S induction damper and/or valve setting

Table 10 — Measurements to be made for each product type

	DD	IU	IFP	IFS
p_{s1}	X	X	X	X
p_{s2}	X	X	X	X
Δp_1	—	X	X	X
Δp_2	—	X	X	X
Δp_{1w}	X	—	—	—
Δp_{1c}	X	—	—	—
θ_1	—	X	X	X
θ_2	X	X	X	X
θ_3	—	X	X	X
θ_{1w}	X	—	—	—
θ_{1c}	X	—	—	—
S	—	X	—	—
n	—	—	—	X

7.3 Test installation

7.3.1 Air supply

The units shall be connected to a suitable air supply system as shown typically in Figures 3 and 5.

7.3.2 DD Units

For DD units , an extension duct of internal dimensions equal to those of the unit outlet and length d_{e2}, shall be connected to the unit outlet as shown in Figure 3.

7.3.3 IU, IFS and IFP units

IU, IFS and IFP units shall be installed with an auxiliary fan as shown in Figure 5 by which method the downstream resistance can easily be modified by adjusting the auxiliary fan speed.

7.3.4 Heating or cooling

The heating or cooling facilities provided shall be capable of producing an air temperature in the warm inlet duct at least 20 K higher than that in the cold inlet duct.

Performance of static pressure measurement device is described in annex A.

7.3.5 Measuring of discharge air temperature

For single duct outlet unit tests, within the extension duct at a plane of 0,5 d_{e2} from the unit outlet, measure the air temperature at a minimum of four points. These points shall be equispaced and symmetrically disposed about the outlet duct centre-line (see Figure 3). No measurement point shall be closer than 25 mm to the duct wall and the maximum distance between points shall be 100 mm.

For multiple outlet unit tests, within the extension ducts at planes 0,5 d_{e2} from the unit outlets, measure air temperatures at the four points shown in Figure 3.

7.3.6 Measuring of primary air inlet temperature

Measurement of air temperature(s) should be taken in the primary air inlet(s) at four points as described for the circular outlet duct in Figure 3. Calculate the mean value for these four readings and record as θ_1.

7.4 Test procedure

The parameters applicable for each type of unit to be tested are shown in Table 11.

Table 11 — Parameters affecting temperature mixing efficiency

Unit type	Parameters
DD	q_{v1c}/q_{v1w}
IU	p_{s1} p_{s2} $q_{\upsilon 1}$ S
IFS	p_{s2} $q_{\upsilon 1}$
IFP	p_{s2} $q_{\upsilon 1}$ n

Set the supply fan running:

a) In the case of the DD unit, adjust the flow rate in each of the inlet ducts to an equal value with the inlet duct static pressures maintained to within ±5 % of the nominal value.

b) For all other units, use the auxiliary fan to control the selected fixed values of outlet duct static pressure.

Set the air temperatures in the inlet ducts (type DD) or inlet duct and induction port (all other types) such that the temperature difference is at least 20 K. Allow a time period of 30 min for stabilization to take place before proceeding with test measurements. During this stabilization period, and throughout the time of test measurements, the inlet air temperatures shall not vary by more than 0,5 K from their mean values.

Table 12 shows the combinations of parameters at which recordings should be made.

Table 12 — Test parameters

Parameter		DD	IU	IFS and IFP
Inlet duct static pressure	p_{s1}	mean	mean	mean
Outlet duct static pressure	p_{s1}	—	25; 50; 75	50
Primary air flow rate		—	min	min
Primary air flow rate ratio	$q_{\upsilon 1c}/q_{\upsilon 1w}$ %	25; 50; 75	—	—
Temperature difference	$\Delta\theta$	≥ 20	≥ 20	≥ 20
Fan speed control setting	n	—	—	max
Position of valve or damper	S	—	open	—

Where max., mean and min. are referred to, values shall be those recommended by manufacturer based on the operational range of the parameter.

For each of the combinations of parameters in Table 12 test measurements should be made as detailed in Table 10.

Test measurements should only be taken when all the parameters of Table 12 have stabilized.

7.5 Calculation of test results

Calculate the temperature mixing efficiency (*TME*) as follows:

$$TME = \left(1 - \frac{2SD}{\Delta\theta_1} \right) 100 \tag{12}$$

where

SD = Standard Deviation from the mean air temperature in the outlet.

$$SD = \sqrt{\frac{\sum_{i=1}^{N} (\theta_{2_i} - \overline{\theta_2})^2}{N - 1}} \tag{13}$$

N = Total number of readings in the outlet

$\overline{\theta_2}$ = Mean air temperature in the outlet

$$\overline{\theta}_2 = \sqrt{\frac{\sum_{i=1}^{N} {\theta_{2i}}^2}{N}}$$

$\Delta\theta_1$ = Mean air temperature difference between inlets

$\Delta\theta_1 = \theta_{1w} - \theta_{1c}$ for DD

$\Delta\theta_1 = \theta_1 - \theta_3$ for IU; IFS; IFP

θ_{2i} = Temperature readings

7.6 Presentation of test results

The test results shall be reported in accordance with Table 13.

Table 13 — Test results to be reported

Test result	DD	IU	IFS	IFP
p_{s1}	X	X	X	X
p_{s2}	—	X	X	X
q_{v1}	—	X	X	X
q_{v1c}/q_{v1w}	X	—	—	—
$\Delta\theta_1$	X	X	X	X
n	—	—	X	X
S	—	X	—	—
TME	X	X	X	X

8 Tests to determine leakage rates

8.1 Principle

This test is to determine the leakage past either the valves of a dual duct unit (type DD) and/or the valve of a variable flow rate controller if designed to go full shut off.

NOTE 1 If the valve is installed within the casting of the unit this test will also include the leakage of the casing upstream of the valve.

NOTE 2 Since small flow rates exist during the closed valve condition, the method used to measure these small flow rates will introduce a high pressure loss when the valve is open. This precludes a high pressure upstream of the valve until it approaches the closed position. As the valve is closed and the flow rate decreases the inlet static pressure will increase to approximately the recommended inlet pressure.

This test is also to determine the total casing leakage including the valve section.

8.2 Test measurements

a) p_{s1} The inlet static gauge pressure in Pa.

b) Δp The flow meter pressure difference (or the appropriate parameter that relates to the air flow rate q_{v1}) in Pa.

8.3 Test installation for valve leakage

Connect an air supply duct, as shown typically in Figure 2, to the inlet of the valve; all other inlets and outlets of the assembly should be open.

Performance of static pressure measurement is described in annex A.

NOTE 1 The duct can be connected to the same type of air supply system used to determine the flow rate control characteristics (see Figure 2).

NOTE 2 The term actuator used in the following text can imply electric, pneumatic or system powered.

8.4 Test procedure

8.4.1 Positioning of valve

The valve(s) shall always be operated by means of the actuator intended for use with the unit.

At the start of each test, and without the supply air system operating, cycle the valve 10 times between the fully open and fully closed positions by means of its actuator, concluding with the valve in the fully closed position.

8.4.2 Testing (all units)

Carry out the tests using each of the applicable inlet test pressures selected by the manufacturer from Table 14.

With supply air system operating, increase the supply air pressure up to the selected pressure. Then, without any additional adjustment of the supply air system flow rate, modulate the valve by means of its actuator to the fully open position and then return it to the fully closed position. As the valve nears closure, adjust the supply air pressure to maintain within ±5 % the specified inlet static gauge pressure.

Table 14 — Inlet pressures

Pressure (Pa)	200; 400; 1 000

8.4.3 Testing (Type DD units)

For dual duct units with the flow rate control function integral with the inlet valves, carry out the procedure on both inlet valves. If the flow rate control function is independent of the inlet valves, carry out the procedure on both inlet valves with the flow rate control valve fully open and on the flow rate control valve itself.

8.4.4 Measurements

When the valve is fully closed, record the measurements in accordance with 8.2.

8.5 Test installation — Casing leakage

8.5.1 Air supply

Connect an air supply system as shown typically in Figure 2 to the inlet of the unit under test (either inlet for a type DD unit). Seal all other inlets and outlets. If a proportioning valve is incorporated in a type DD unit, set it to the middle position.

For a type IFS unit fitted with a non-return damper, the damper shall close under the system pressure without the aid of additional sealing.

Performance of static pressure measurement device is described in annex A.

8.5.2 Test procedure

Carry out the tests using each of the applicable inlet test pressures selected by the manufacturer from Table 14. With the supply air system in operation, adjust the air pressure to the selected test pressure.

Maintain the pressure until stable conditions are achieved. If an integrating flow meter is employed, do not commence measurements until 180 s after the test pressure has been reached.

8.5.3 Measurements

Record the measurements in accordance with 8.2.

8.6 Calculation of test results

8.6.1 Volume air flow rate

Determine the volume air flow rate (leakage rate) q_{v1} (l.s^{-1}) at the flow meter for both the valve and casing tests.

8.6.2 Damper leakage

Calculate at each test pressure reference, the leakage volume flow rate to the inlet duct cross-sectional area:

$$q_{\mathrm{vLBA}} = \frac{q_{v1}}{A_1} \qquad (14)$$

8.6.3 Casing leakage

Calculate at each test pressure reference the leakage volume flow rate to the net surface area of the unit:

$$q_{\mathrm{vLCA}} = \frac{q_{v1}}{A_1} \qquad (15)$$

The nett surface area is defined as the gross surface area of the unit less the sum of all inlet and outlet areas.

8.7 Presentation of the test results

8.7.1 Damper leakage

Report the test results as the next lowest classification according to Figure 8, to which the value of the leakage rates apply at the test pressures.

EXAMPLE

Primary air inlet diameter	d_1 = 250 mm
Cross sectional area	A_1 = 0,049 m^2
Flow rate	q_{vl} = 0,29 l·s·^{1}
	q_{vLBA} = 6 l·s^{-1}·m^{-2}
Test pressure	p_{s1} = 400 Pa
Result:	**Class “3” at 400 Pa.**

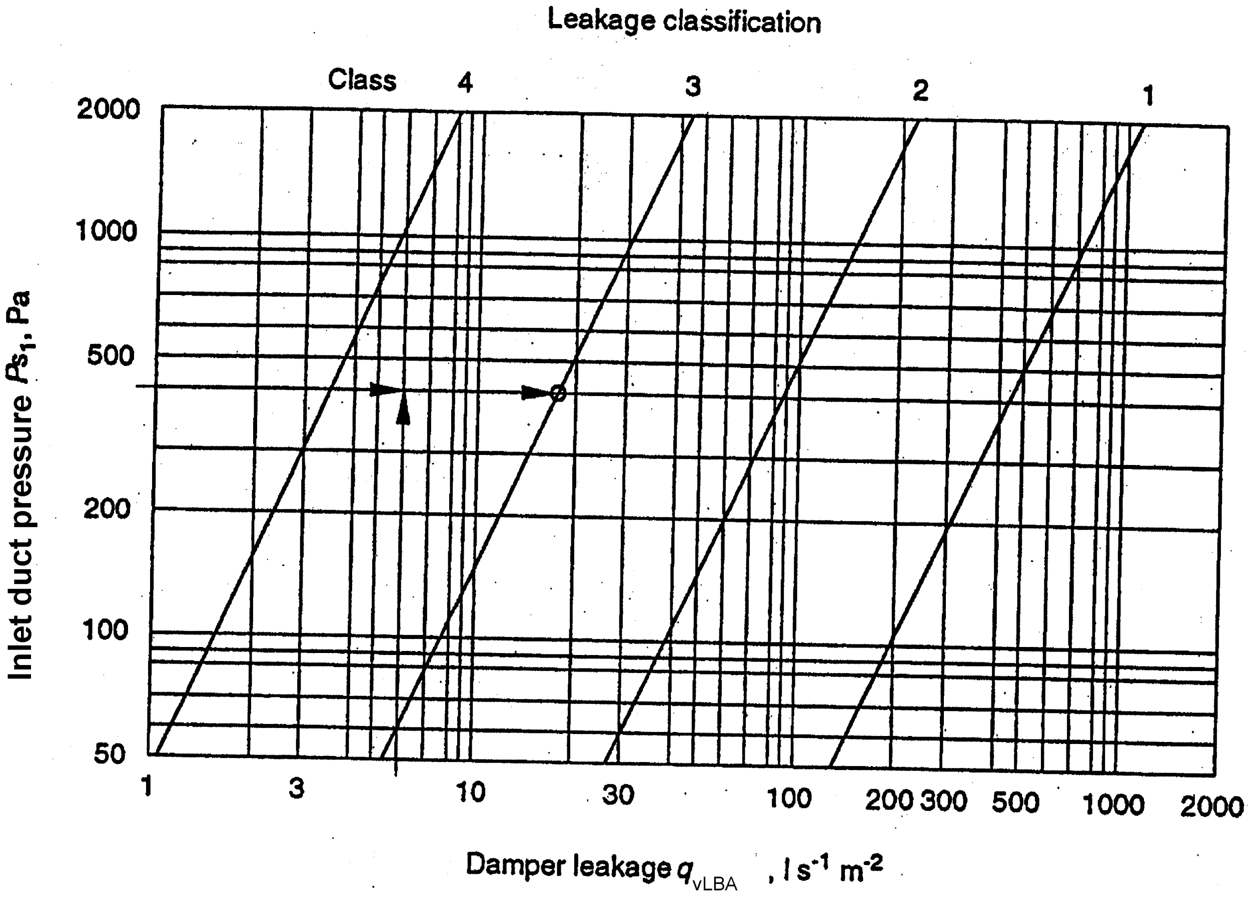


Figure 8 — Damper leakage classification (see example in 8.7.1)

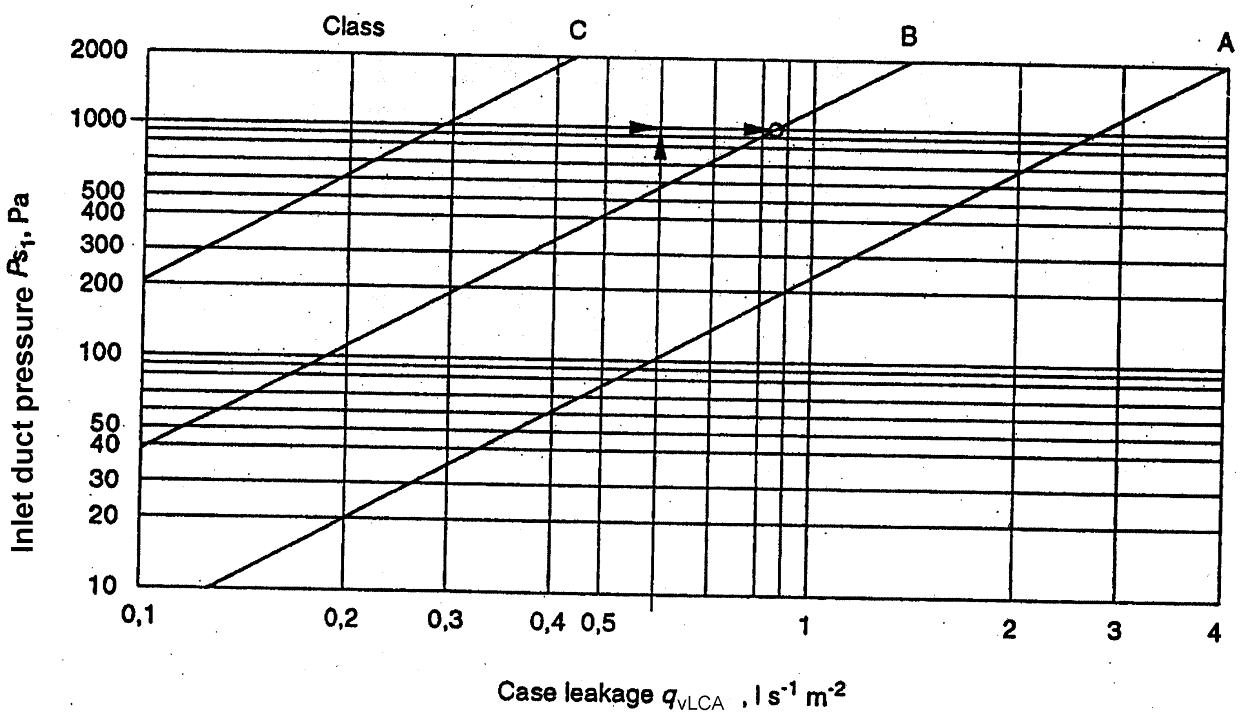


Figure 9 — Case leakage classification (see example in 8.7.2)

8.7.2 Casing leakage

Report the test results as the next lowest Classification according to Figure 9, to which the value of the leakage rates apply at the test pressures.

EXAMPLE

Terminal unit size 450 mm wide x 250 mm high x 1 250 mm long

Gross area 0,45 m x 1,25 m x 2 = 1,124 m^2

0,25 m x 1,25 m x 2 = 0,625 m^2

0,45 m x 0,25 m x 2 = 0,225 m^2

1,975 m^2

Less:

Primary air inlet d_1 = 200 mm

Cross sectional area A_1 = 0,031 5 m^2

Outlet area (0,45 m x 0,25 m) A_2 = 0,1125 m^2

Total = 0,144 m^2

Therefore, net surface area 1,975 m^2 - 0,144 m^2 = 1,831 m^2

Flow rate q_{v1} = 1,1 $l.s^{-1}.m^{-2}$

q_{vLCA} = 0,6 $l.s^{-1}m^{-2}$

Test pressure p_{s1} = 1 000 Pa

Result: Class “B” at 1 000 Pa

Annex A
(normative)
Determination of static pressure

A.1 Pressure determination

The unit under test shall be mounted in a system which meets the requirements as typically shown in Figure 2.

The test ducts shall have cross-sectional dimensions equal to the nominal size of the unit under test or to the manufacturer's instructions.

Flow straighteners shall be fitted in the upstream test duct at a position 3 d_e from the connection to the unit under test. Alternatively, a straight duct in accordance with ISO 5167-1 can be used without flow straighteners.

The velocity profile near the upstream connection to the unit under test shall be uniform to within ±10 % of the mean value over the test duct cross-section, excluding the area within 15 mm of the duct walls.

A.2 Static pressure

The upstream duct static gauge pressure (p_{s1}) shall be measured by means of four static pressure tappings 1,5 d_e from the upstream connection to the unit under test. For a rectangular duct, the pressure taps shall be at the centre of each side, and, for a circular duct, equally spaced around the circumference. The pressure taps shall be connected to form a piezometric ring. Alternatively, a single pitot static probe may be used.

A.3 Total pressure

The total pressure is calculated by using the measured static pressure as described in 5.5.

Alternatively, a pitot tube may be used for direct measurement if the total pressure, providing the conditions of A.1 have been met.

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