International Standard ISO 5220

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Air distribution and air diffusion — Aerodynamic testing and rating of constant and variable dual or single duct boxes and single duct units

Distribution et diffusion d'air — Méthodes d'essais aérauliques et présentation des caractéristiques des boîtes à simple ou double conduit, à débit fixe ou réglable, et des appareils à simple conduit

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5220 was developed by Technical Committee ISO/TC 144, *Air distribution and air diffusion*, and was circulated to the member bodies in November 1979.

It has been approved by the member bodies of the following countries :

Austria	Germany, F.R.	Sweden
Belgium	Italy	United Kingdom
Czechoslovakia	Korea, Rep. of	USA
Finland	Romania	
France	South Africa, Rep. of	

No member body expressed disapproval of the document.

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Air distribution and air diffusion — Aerodynamic testing and rating of constant and variable dual or single duct boxes and single duct units

Section one : General

1 Scope

This International Standard specifies methods for the aerodynamic testing and rating of assemblies suitable for use with air distribution systems operating at high or low velocity and high or low pressure.

The tests included in this International Standard cover :

a) leakage past a closed inlet valve or control valve;

b) casing leakage;

c) characteristics of the constant or variable flow rate controller;

d) degree of temperature mixing achieved by a dual duct box;

e) flow rate characteristics for single duct units.

These tests are designed to determine the performance of the assemblies and the results will enable the comparison of suitability of such assemblies when correctly installed in a high or low velocity/pressure air distribution system.

2 Field of application

The following tests are applicable to each class of equipment as indicated :

2.1 Dual duct boxes :

a) test for control valve leakage;

b) test for casing leakage;

c) test for flow rate control (constant or variable);

d) test for temperature mixing.

2.2 Single duct boxes :

a) test for control valve leakage;

b) test for casing leakage;

c) test for constant flow rate control;

d) test for variable flow rate control :

— throughout the operating range;

— if capable of being reduced to zero;

— if fitted with an inlet valve.

NOTE — Assemblies with variable primary flow rate control devices with induced flow facilities (induction boxes) will be the subject of an addendum to this International Standard.

2.3 Single duct units :

a) test for casing leakage;

b) test for flow rate characteristics.

3 References

ISO 3258, *Air distribution and air diffusion — Vocabulary.*

ISO 5221, *Air distribution and air diffusion — Guide to methods of measuring air flow rate in an air handling duct.*[1)]

4 Definitions

The definitions of terms used in this International Standard are in accordance with ISO 3258.

1) At present at the stage of draft.

5 Symbols and abbreviations

The following nomenclature is used throughout this International Standard :

5.1 Symbols

Table 1

Symbol	Quantity	Corresponding SI unit	Dimensions
A	Internal cross-sectional area of duct	m^2	L^2
D_e	Equivalent diameter $\sqrt{\frac{4A}{\pi}}$	m	L
p	Absolute static pressure	Pa	$M\ L^{-1}\ T^{-2}$
p_a	Atmospheric pressure	Pa	$M\ L^{-1}\ T^{-2}$
p_d	Velocity pressure $\varrho \frac{v^2}{2}$	Pa	$M\ L^{-1}\ T^{-2}$
p_r	Stagnation (or absolute total) pressure	Pa	$M\ L^{-1}\ T^{-2}$
p_s	Static gauge pressure $(p - p_a)$	Pa	$M\ L^{-1}\ T^{-2}$
p_t	Total pressure $(p_r - p_a)$	Pa	$M\ L^{-1}\ T^{-2}$
Δp	Flow meter pressure difference	Pa	$M\ L^{-1}\ T^{-2}$
Δp_t	Conventional total pressure differential for an air density of 1,2 kg/m^3 at the inlet to the assembly under test	Pa	$M\ L^{-1}\ T^{-2}$
q_v	Volume rate of air flow at the flow meter	m^3/s	$L^3\ T^{-1}$
q_{vL}	Leakage volume rate of air flow through a closed inlet valve or variable flow rate controller set for zero flow[1)]	m^3/s	$L^3\ T^{-1}$
v	Velocity	m/s	LT^{-1}
Δy	Conventional value of energy loss per unit mass	J/kg	$L^2\ T^{-2}$
ϱ	Air density	kg/m^3	$M\ L^{-3}$
Θ	Thermodynamic temperature	K	Θ
θ	Celsius temperature	°C	θ

1) Or the appropriate measurable value, in suitable units, relating to the positional indication of the control valve, or the setting of the variable air flow rate controller, for electric, system-powered or other types of assembly.

5.2 Suffixes

1 is the inlet of the unit under test

2 is the outlet of the unit under test

c is the cold side

h is the hot side

u is the measuring point upstream of the flow meter

6 Instrumentation

6.1 Air flow rate measurement

The air flow rate shall be measured using instruments in accordance with ISO 5221.

6.1.1 Air flow meters shall have the following ranges and accuracies :

Table 2

Range m^3/s	Accuracy of measurement %
From 0,07 to 7	2,5
From 0,007 to 0,07	5

Flow meters may be calibrated *in situ* by means of the pitot-static tube traverse techniques described in ISO 5221.

6.1.2 Leakage air flow meters shall have the following ranges and accuracies :

Table 3

Range m^3/s	Accuracy of measurement
Up to and including 0,018	0,000 9 m^3/s
More than 0,018	5 %

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 the specifications given in 6.1.3 c).

6.1.3 Flow meters shall be checked at intervals as appropriate but not exceeding 24 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 the initial calibration of meters calibrated at the test installation;

c) a check against a flow meter which meets the requirements of ISO 5221.

6.2 Pressure measurement

6.2.1 Pressure in the duct shall be measured by means of a liquid-filled calibrated manometer.

6.2.1.1 The maximum scale interval shall not be greater than the characteristics listed for the accompanying range of manometer.

Table 4

Range Pa	Maximum scale interval Pa
From 1,25 to 25	1,25
From 25 to 250	2,5
From 250 to 500	5,0
Above 500	25

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

a) 25 Pa with an inclined tube manometer or micromanometer;

b) 500 Pa with a vertical tube manometer.

6.2.1.3 Calibration standards shall be :

a) for instruments with the range 1,25 to 25 Pa, a micromanometer accurate to ± 0,25 Pa;

b) for instruments with the range 25 to 500 Pa, a manometer accurate to ± 2,5 Pa (hook gauge or micromanometer);

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

6.3 Temperature measurement

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

Section two : Testing and analysis of test results

7 Leakage tests

7.1 Valve leakage

It is intended to measure control valve leakage or leakage past a variable flow rate controller in the shut off position under conditions of actual operation with the valve closing against the maximum recommended static pressure conditions. Since small flow rates exist during the closed valve condition, the flow rate means used to measure these small flow rates will have a high pressure loss when the valve is open. This precludes a high pressure in the inlet duct until the valve approaches the closed position. As the valve is closed and the flow rate decreases, the inlet static pressure will increase to approximately the recommended maximum inlet pressure.

a) **Dual duct boxes;** with no air flow, the inlet control valve shall be positioned such that the inlet under test is fully closed by the actuator.

b) **Single duct boxes;** with inlet valve, control valve or a flow rate controller capable of acting as a valve, the valve shall be positioned such that it is fully closed by the actuator with no air flow.

c) **Single duct units;** with inlet valve or control valve, the valve shall be positioned such that it is fully closed by the actuator with no air flow.

In all cases, the valve or control valve shall be held in the closed position by means of the actuator recommended for use with the box.

7.1.1 An air supply duct similar to that specified in figure 1 shall be connected to the inlet of the closed valve or control valve. All other apertures in the assembly shall be open.

7.1.2 The air supply duct (see figure 1) shall be connected to a suitable air supply system that is preferably of the same type as used to determine the characteristics of the measured pressure differential versus air flow rate.

7.1.3 The supply air pressure shall be increased to the maximum recommended inlet pressure, then, without any additional adjustment of the supply air system flow rate, the assembly inlet control valve shall be modulated to the open position and then returned to the closed position by means of the actuator. As the valve nears closure (as governed by the recommended maximum or minimum operating signal to the actuator) the supply air pressure shall be adjusted so as to maintain the maximum recommended inlet static gauge pressure to within ± 5 %. The air flow rate shall be recorded as the control valve leakage rate expressed in the form X m³/s at Y Pa.

7.1.4 In the case of dual duct inlet boxes, the test shall be repeated on the other inlet, and the control valve leakage quoted as X m³/s at Y Pa cold inlet and Z m³/s at Y Pa hot inlet.

1) Or the appropriate parameter which relates to the air flow rate q_V.

7.2 Casing leakage

7.2.1 The air supply system described in 7.1.1 and 7.1.2 shall be connected to the inlet of the device under test (either inlet for a dual duct box). All other inlets and the outlets shall be sealed and the proportioning valve (where fitted) set to the position where both inlet flows would be equal.

7.2.2 The test of the low pressure section of the device under test shall be carried out by subjecting the whole of the device under test to a static gauge pressure of 200 Pa or the maximum recommended pressure (relative to the low pressure section), whichever is the greater. The pressure shall be maintained for 60 s before the measurement of leakage commences.

7.2.3 The test of the high pressure section of the device under test shall be carried out at a static gauge pressure of 1 500 Pa, or the maximum recommended pressure if this is greater than 1 500 Pa. This test pressure shall be maintained for a minimum period of 5 min before measurements are recorded.

NOTE — If an integrating flow meter is employed, measurement may commence 3 min after the test pressure is reached.

7.2.4 The test results shall be reported as leakage flow rate at the test pressures used.

8 Test of flow rate control

This test will indicate the pressure differential at which the controller commences to operate (minimum operating pressure differential), and the changes in flow rate resulting from the variation in the pressure differential between the inlet duct(s) and the outlet ducts, and, for dual duct boxes, at different positions of the inlet valves.

8.1 Tests for constant flow rate characteristics

8.1.1 The test installation requirements are shown in figures 2 and 3.

8.1.2 The following measurements shall be made during the tests described in the following clauses :

p_{s1} inlet duct static gauge pressure in pascals;

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

θ_1 air temperature at inlet to unit under test in degrees Celsius;

Δp[1] flow meter pressure difference in pascals;

p_{su} static gauge pressure immediately upstream of the flow meter in pascals;

θ_u air temperature immediately upstream of the flow meter in degrees Celsius.

The atmospheric pressure shall be noted at the beginning and end of the tests.

8.1.3 The following test shall be carried out for each of the valve settings described in 8.1.5. The pressure differential between inlet(s) and outlet(s) shall be increased to 1 500 Pa, or to the recommended maximum operating pressure differential whichever is greater, and the specified measurements (see 8.1.2) shall be made and recorded at that pressure differential. The pressure differential shall be decreased to approximately the next value on the R 10 series given below and the test repeated at approximately each subsequent value, 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.

. . . 2 500, 2 000, 1 600, 1 250, 1 000, 800, 630, 500, 400, 315, 250, 200, 160, 125 . . . Pa.

Should the pressure be allowed to fall below the next prescribed value, it must be increased to the value at the start of the test and then slowly decreased to the prescribed value before a further measurement is taken.

The specified measurements (see 8.1.2) shall be recorded at each pressure differential level. The pressure differential shall then be reduced to zero and then restored to the level at which the last measurement was made. The pressure differential shall then be increased up to the maximum pressure differential used as the starting point in intervals not exceeding those in the above series. The specific measurements shall be recorded at each pressure differential level.

Should the pressure be allowed to rise above the next prescribed value it must be decreased to the minimum value and slowly increased to the prescribed value before a further measurement is taken.

8.1.4 The flow rate controller shall be set to its maximum flow, the fan started and the desired inlet static pressure set.

8.1.5 For dual duct boxes only, the test in 8.1.3 shall be carried out with the hot duct inlet valve set 100 %, and approximately 50 % and 25 % open as determined by the valve-controlling device. For non-symmetrical units, the test in 8.1.4 shall be carried out with the hot duct inlet valve set 100 %, and approximately 75 %, 50 % and 25 % open and then in the fully closed position.

8.1.6 The foregoing tests shall be repeated with the constant flow rate controller at its mid-range and minimum settings. If a controller is to be tested at any other specific values within its operating range, the foregoing procedure shall also be used.

For variable flow rate controllers refer to 8.2.1, 8.2.2 and 8.2.3.

8.1.7 For each test, determine the volume air flow rate at the flow meter (q_v). If there are significant differences in the air temperature and static pressure between the flow meter and the unit under test so that the air density ratio ϱ_u/ϱ_1 is less than 0,98 or greater than 1,02, then the following correction should be applied :

$$q_{v1} = q_v \frac{\varrho_u}{\varrho_1}$$

where

$$\varrho_u = 3{,}47 \times 10^{-3} \left[\frac{p_{su} + p_a}{\theta_u + 273} \right]$$

and $$\varrho_1 = 3{,}47 \times 10^{-3} \left[\frac{p_{s1} + p_a}{\theta_1 + 273} \right]$$

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

For each test, Δy shall be calculated by use of the following equation :

$$\Delta y = \left[\frac{p_{s1} - p_{s2}}{\varrho_1} + \frac{q_{v1}^2}{2} \left(\frac{1}{A_1^2} - \frac{1}{A_2^2} \right) \right]$$

For standard reference conditions

$$\Delta p_t = 1{,}2\ \Delta_y$$

A graph shall be drawn of Δp_t (or Δy) against q_{v1}

8.1.8 Minimum operating pressure differential[1)]

The minimum operating pressure differential of an assembly is defined as the highest pressure differential at the lower end of the operating range at which any Δp_t against q_{v1} graphs plotted from the results obtained from the tests described above intersects one of the lines representing the boundaries of a selected tolerance band.

Whenever the test installation illustrated in figure 3 is used, then the pressure losses of the dividing ducting and connections to the inlets of the box must be determined so that they can be deducted from the minimum operating pressure differential.

Examples are shown in figure 4.

1) The procedure described 8.1.8 may also be followed based on the energy loss per unit mass from a plot of Δy against q_{v1}.

8.2 Additional tests for variable flow rate controllers

8.2.1 Boxes with variable rate of air flow controlled from stated maximum to stated minimum

The tests described in 8.1.3, 8.1.4 and 8.1.5 shall be carried out with the externally applied control signal set at levels such that the variable flow rate controller(s), or system, delivers the maximum and minimum stated flow rates for the maximum, mid-range and minimum settings of the controller(s).

8.2.2 Boxes with variable rate of air flow controlled from stated maximum to substantially zero

The tests described in 8.1.3, 8.1.4 and 8.1.5 shall be carried out with the externally applied control signal set at levels such that the variable flow rate controller(s), or system, delivers 100 % and approximately 40 % of the maximum air flow rate of the box for the maximum, mid-range and minimum settings of the controller(s).

The "substantially zero" rate of air flow shall then be determined for the maximum setting only as in 7.1, 7.1.1, 7.1.2 and 7.1.3 and reported as q_{vL} in m^3/s.

8.2.3 Dual duct boxes

For dual duct boxes only, the tests described in 8.2.1 and 8.2.2 with control signals at other than the 100 % setting shall be carried out with the hot air duct inlet valve closed.

9 Test for flow rate characteristics of single duct units

9.1 These tests will indicate the pressure differential of the unit at flow rates throughout the operating range with the damper fully open.

9.2 The requirements to be met by the test installation are shown in figure 2.

9.3 The measurements described in 8.1.2 shall be made during the tests.

9.4 The tests shall be conducted at a minimum of five air flow rates distributed evenly throughout the flow rate range of the device under test. The lowest flow rate shall be chosen so that the inlet duct static gauge pressure is not less than 10 Pa.

9.5 For each test, the procedure outlined in 8.1.7 shall be followed.

9.6 A graph shall be drawn of the five or more values of lg Δp_t (or lg Δy) against lg q_{v1} as shown in figure 6. This graph relates the pressure differential of the device to the air flow rate through the device.

10 Test of temperature mixing efficiency

These tests will indicate the efficiency of the mixing of the hot and cold air entering the mixing box.

10.1 Testing

The general arrangements of a typical test installation for these tests is given in figure 5 which also defines the temperature measuring stations.

10.1.1 Single outlet box

For outlet temperature measurements in testing single outlet boxes, a minimum of four measurement points shall be employed with no point closer than 25 mm to a duct wall and the maximum distance between points shall be 100 mm. Temperature measuring points shall be symmetrically disposed about the outlet duct centre line.

An example of such an arrangement is shown in figure 5.

10.1.2 Multiple outlet box

For tests on multiple outlet boxes, the numbers and position of the temperature measuring points at each outlet shall be as described in 10.1.1 for such tests. Each outlet shall be fitted with straight lengths of ducting. At the discharge end of these outlet ducts, identical resistance screens (or perforated plates) having no more than 60 % free area shall be fitted.

10.2 Test procedure

No measurement of air flow rate is required. Before the full outlet temperature traverse is made, the air flow rate ratio in the two inlet ducts shall be calculated from the relationship between the inlet air temperatures and the outlet air temperature measured at the centre of the outlet duct in the measurement plane. The tests shall be carried out at approximately the maximum and minimum settings of the flow rate controller of the assembly and at inlet flow ratios of 1:1, 1:3 and 3:1.

The inlet pressure shall be above the minimum operating pressure. The difference of the mean temperature of the air in the two inlet ducts shall be not less than 20 K.

The outlet temperature differential in each test is defined as the difference between the measured maximum and minimum temperatures.

The outlet temperature differential measured in each test shall be reported for each 10 K difference in inlet temperature.

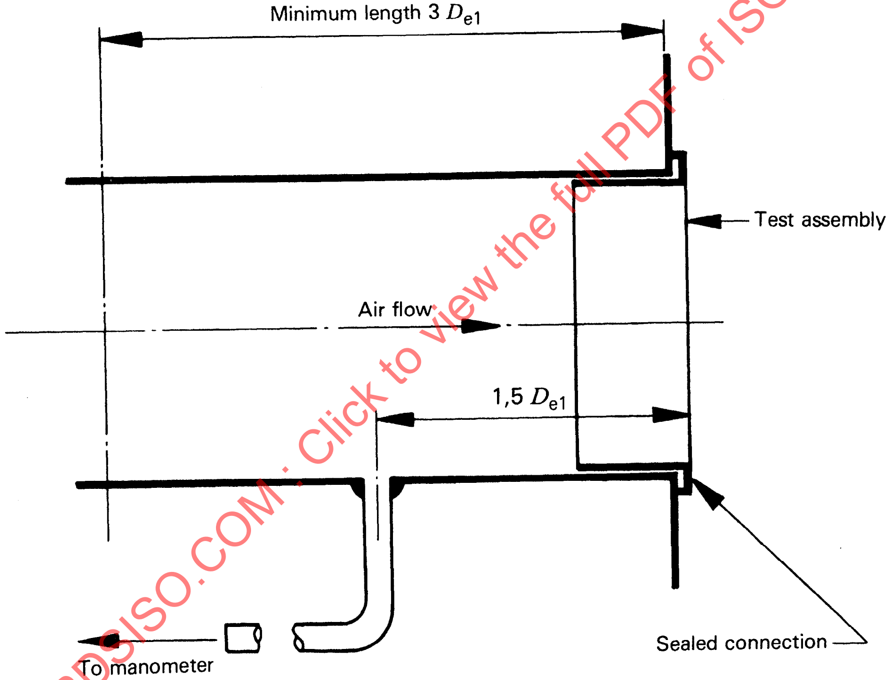

Figure 1 — Leakage test, air supply duct

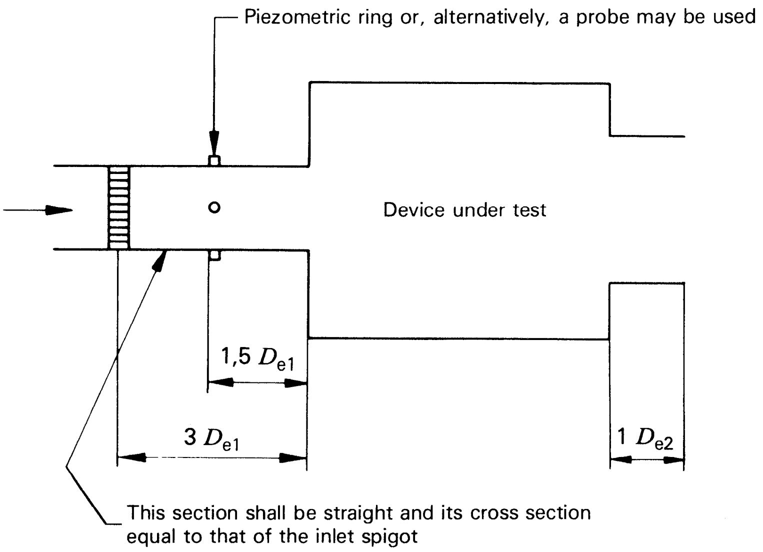

Figure 2a) — Free discharge

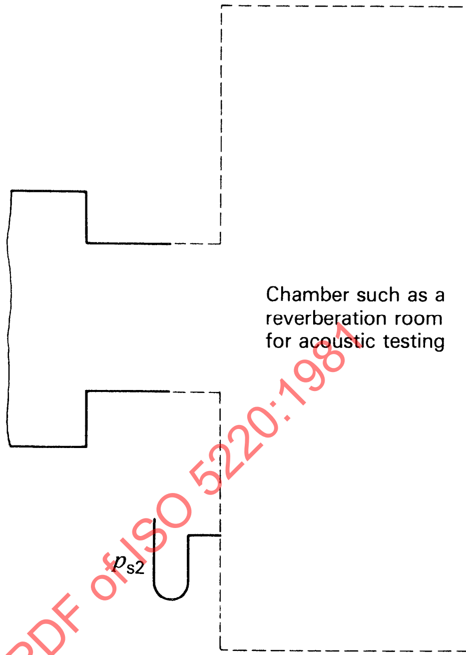

Figure 2b) — Discharge into chamber

Figure 2 — Typical air supply arrangement for tests on single duct boxes and/or units

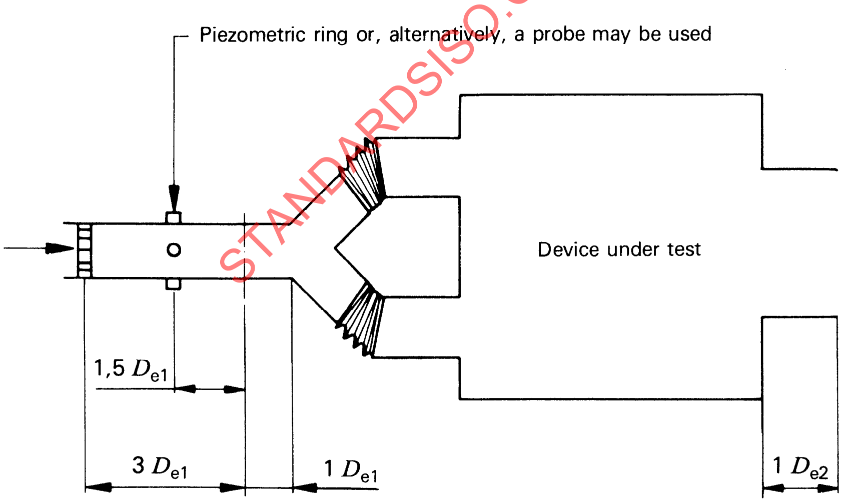

Figure 3a) — Free discharge

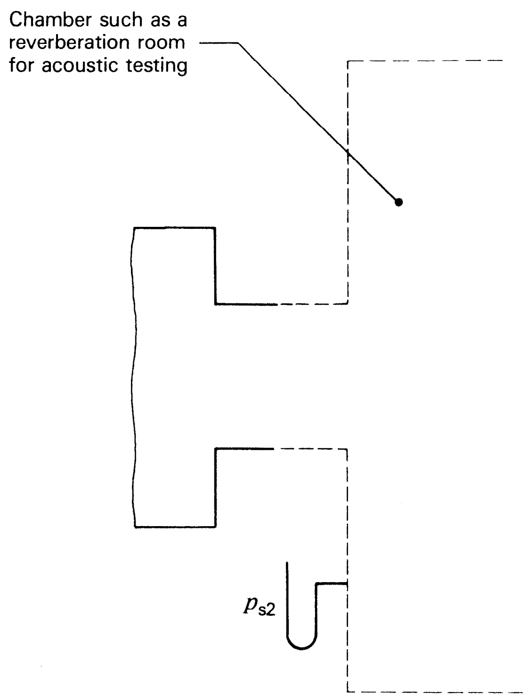

Figure 3b) — Discharge into chamber

Figure 3 — Typical air supply arrangement for tests on dual duct boxes

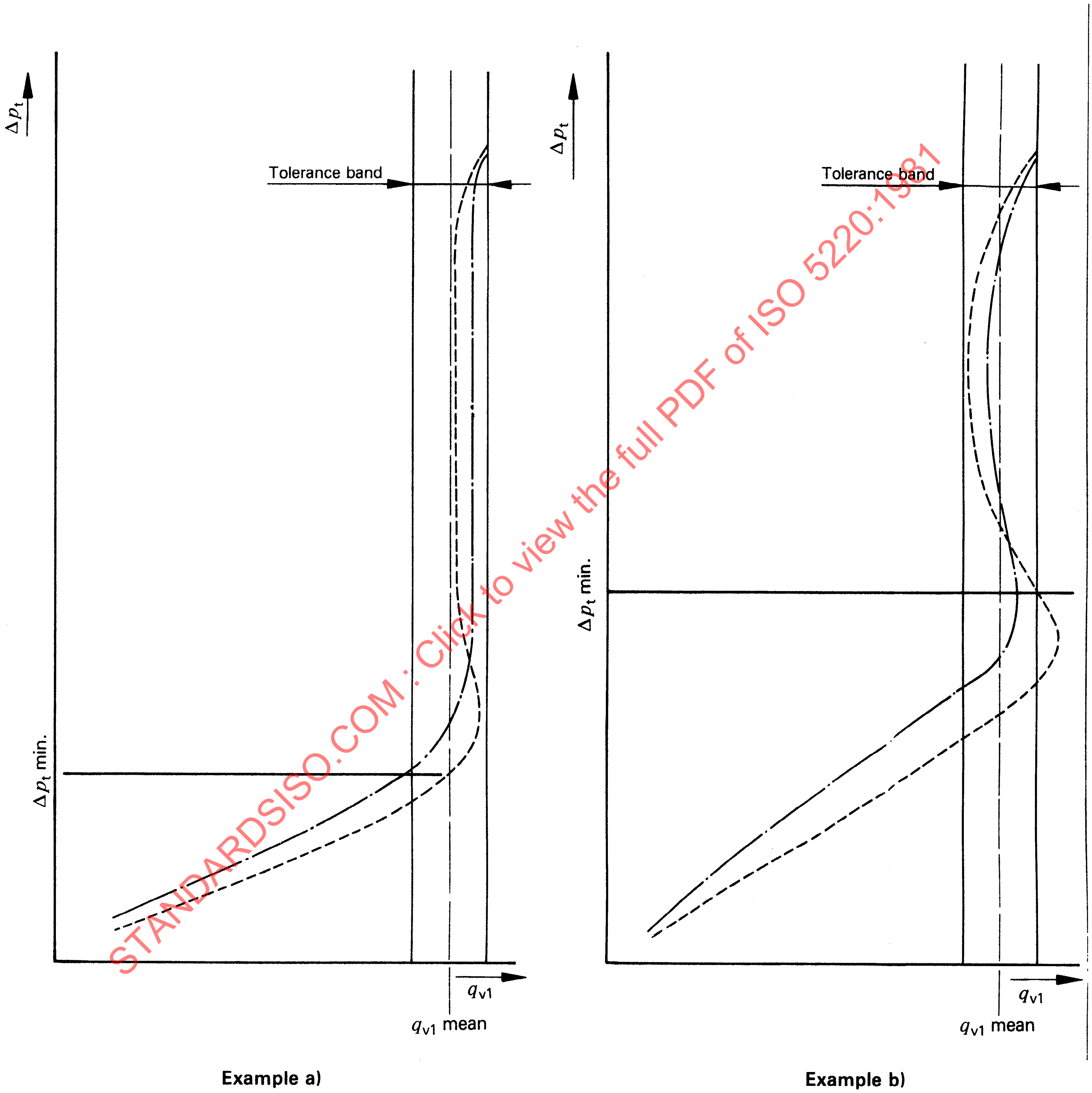

Figure 4 — Examples of the determination of "minimum pressure differential"

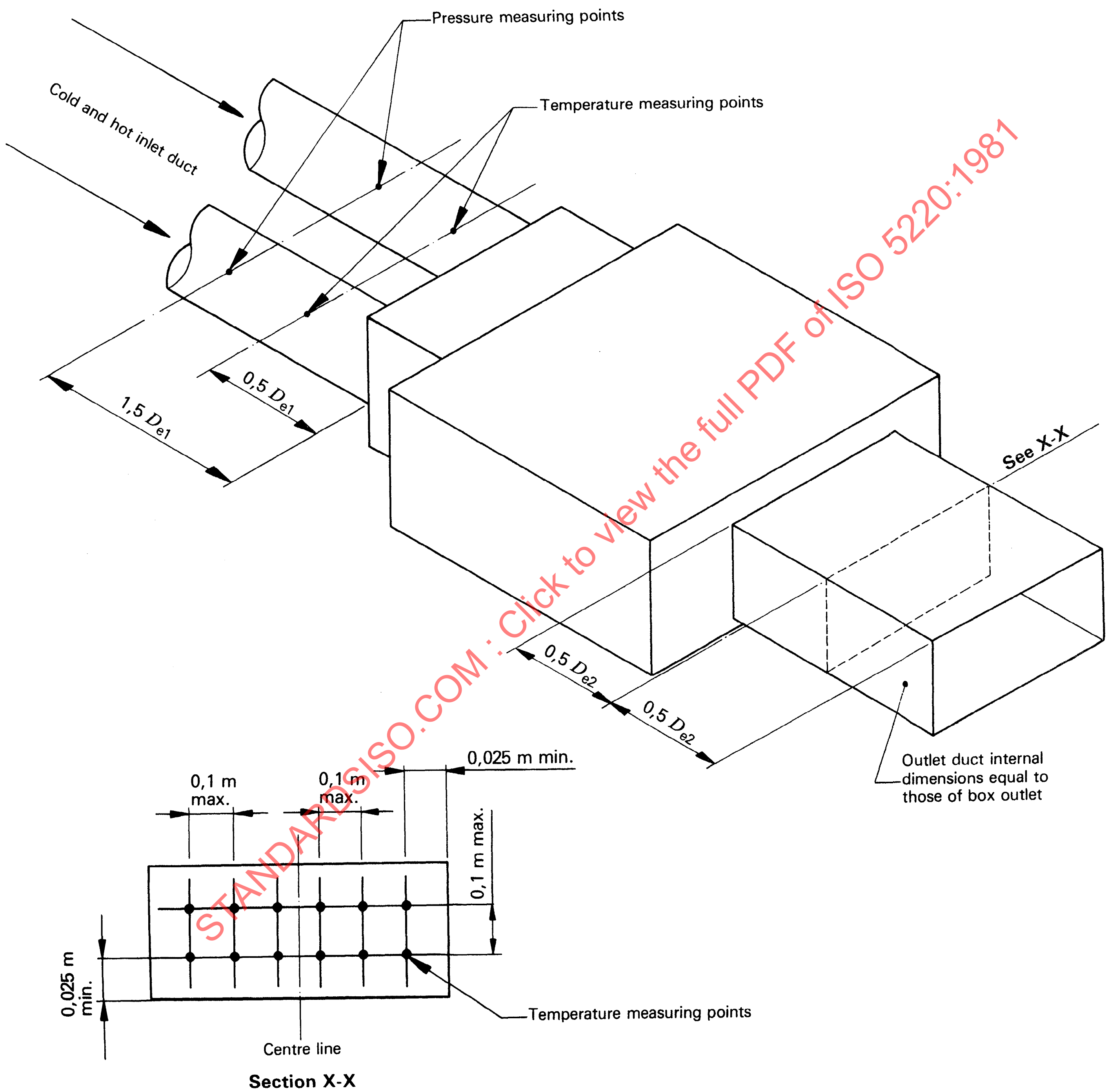

Figure 5 — General arrangement of a temperature mixing test installation