INTERNATIONAL STANDARD

ISO 27327-1

First edition
2009-06-15

Fans — Air curtain units —

Part 1: **Laboratory methods of testing for aerodynamic performance rating**

Ventilateurs — Rideaux d'air —

Partie 1: Méthodes d'essai en laboratoire des caractéristiques de performance aérodynamique

Reference number
ISO 27327-1:2009(E)

Contents

Page

Foreword ... iv

Introduction ... v

1 Scope ... 1

2 Normative references ... 1

3 Terms, definitions and symbols ... 1
3.1 Terms and definitions ... 1
3.2 Symbols ... 6

4 Air curtain airflow rate test ... 8
4.1 Apparatus and instruments ... 8
4.2 Preparation of air curtain airflow rate test ... 8
4.3 Test procedure ... 8
4.4 Calculation ... 9
4.5 Test report ... 11

5 Outlet air velocity uniformity test ... 11
5.1 Apparatus and instruments ... 11
5.2 Air velocity projection and outlet air velocity uniformity test ... 12
5.3 Test procedure ... 12
5.4 Calculation ... 13
5.5 Test report ... 14

6 Air curtain velocity projection test ... 14
6.1 Apparatus and instruments ... 14
6.2 Equipment and organization ... 14
6.3 Test procedure ... 15
6.4 Calculation ... 16
6.5 Test report ... 16

7 Illustration of tests ... 17

Annex A (normative) Uncertainty in velocity determination using Pitot-static tube and manometer ... 28

Bibliography ... 29

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 27327-1 was prepared by Technical Committee ISO/TC 117, *Fans*.

ISO 27327 consists of the following parts, under the general title *Fans — Air curtain units*:

— *Part 1: Laboratory methods of testing for aerodynamic performance rating*

Introduction

This part of ISO 27327 is the first developed by ISO/TC 117 and is intended to determine the aerodynamic performance rating of an air curtain. The principal aerodynamic attributes determined by this part of ISO 27327 are airflow rate, power consumption, velocity uniformity near the exit plane and average air curtain core velocities at specified distances from the exit plane.

While a fan energy efficiency calculation is included in this part of ISO 27327, it is generally recognized by the developers of this part of ISO 27327 that a different measure of energy effectiveness is more important and meaningful than fan efficiency because the energy savings that can be obtained by a properly selected, installed and controlled air curtain are significantly higher than the energy needed to drive the motor(s) of an air curtain. This part of ISO 27327 is developed with the understanding that another test standard can be developed at a later stage, which can define a test method for energy effectiveness.

This part of ISO 27327 is not intended as an *in situ* test International Standard and neither is it applicable to thermodynamic performance.

Fans — Air curtain units —

Part 1: Laboratory methods of testing for aerodynamic performance rating

1 Scope

This part of ISO 27327 establishes uniform methods for laboratory testing of air curtain units to determine aerodynamic performance in terms of airflow rate, outlet air velocity uniformity, power consumption and air velocity projection, for rating or guarantee purposes.

This part of ISO 27327 is not applicable to the specification of test procedures to be used for design, production or field testing.

2 Normative references

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

ISO 5801:2007, *Industrial fans — Performance testing using standardized airways*

3 Terms, definitions and symbols

For the purposes of this document, the following terms and definitions apply.

3.1 Terms and definitions

3.1.1
air curtain airstream
directionally-controlled airstream, moving across the entire height and width of an opening, which can reduce the infiltration or transfer of air from one side of the opening to the other and/or inhibit the passage of insects, dust and debris

3.1.2
air curtain depth
airstream dimension perpendicular to both the direction of airflow and the airstream width

NOTE This is the short dimension of the airstream.

3.1.3
air curtain width
airstream dimension perpendicular to both the direction of airflow and the airstream depth

NOTE This is the long dimension of the airstream.

3.1.4
air curtain unit
ACU
air-moving device which produces an air curtain

3.1.5
air discharge nozzle
component or an assembly in the ACU which directs and controls the airstream

NOTE This may include adjustable vanes.

3.1.6
air discharge nozzle depth
h_{n}
inside dimension perpendicular to both the direction of airflow and the airstream width

NOTE This depth is expressed in millimetres.

3.1.7
air discharge nozzle width
b_{n}
inside dimension perpendicular to both the direction of airflow and the nozzle depth

NOTE This width is expressed in millimetres.

3.1.8
air discharge angle
θ
angle between the plane of the protected opening and the direction in which the air curtain leaves the discharge

3.1.9
dry-bulb temperature
T_{d}
air temperature measured by a dry temperature sensor in the test enclosure, near the ACU inlet or airway inlet

NOTE This temperature is expressed in degrees Celsius.

3.1.10
wet-bulb temperature
T_{w}
air temperature measured by a temperature sensor covered by a water-moistened wick and exposed to air in motion

NOTE 1 When properly measured, it is a close approximation to the temperature of adiabatic saturation.

NOTE 2 This temperature is expressed in degrees Celsius.

3.1.11
air density
ρ_{a}
mass per unit volume of air

NOTE Air density is expressed in kilograms per cubic metre.

3.1.12
pressure
force per unit area

3.1.13
absolute pressure
p
value of a pressure when the datum pressure is absolute zero

NOTE This is always positive.

3.1.14
atmospheric pressure
p_a
absolute pressure of the free atmosphere at the mean altitude of the ACU

NOTE This pressure is normally expressed in pascals.

3.1.15
gauge pressure
p_e
value of the pressure when the datum pressure is the atmospheric pressure at the point of measurement

NOTE 1 Gauge pressure can be negative or positive.

NOTE 2 Gauge pressure is determined using Equation (1):

$$p_e = p - p_a \tag{1}$$

NOTE 3 This pressure is normally expressed in pascals.

3.1.16
dynamic pressure at a point
p_d
pressure calculated from the velocity and the density, ρ_a, of the air at a point

NOTE 1 The point is determined using Equation (2):

$$p_d = \rho_a \left(\frac{v^2}{2} \right) \tag{2}$$

NOTE 2 This pressure is normally expressed in pascals.

3.1.17
gauge stagnation pressure at a point
p_{esg}
difference between the absolute stagnation pressure, p_{sg}, and the atmospheric pressure, p_a

NOTE 1 This pressure is calculated using Equation (3):

$$p_{esg} = p_{sg} - p_a \tag{3}$$

NOTE 2 This pressure is normally expressed in pascals.

3.1.18
ACU airflow rate
q
airflow volume which leaves the discharge nozzle, at standard air conditions, as measured in accordance with ISO 5801

NOTE 1 This is given by Equation (4):

$$q = q_{\mathrm{Vsg1}} \tag{4}$$

NOTE 2 This rate is expressed in cubic metres per second.

3.1.19
inlet stagnation volume flow rate
q_{Vsg1}
mass flow rate divided by the inlet stagnation density

NOTE 1 This is determined using Equation (5):

$$q_{\mathrm{Vsg1}} = \frac{q_{\mathrm{m}}}{\rho_{\mathrm{sg1}}} \tag{5}$$

NOTE 2 Inlet stagnation volume flow rate is expressed in cubic metres per second.

3.1.20
ACU pressure
p_{ACU}
difference between the stagnation pressure at the ACU outlet and the stagnation pressure at the ACU inlet

NOTE 1 This is determined using Equation (6):

$$p_{\mathrm{ACU}} = p_{\mathrm{sg2}} - p_{\mathrm{sg1}} \tag{6}$$

NOTE 2 When the Mach number is less than 0,15, it is possible to use the relationship given in Equation (7):

$$p_{\mathrm{ACU}} = p_{\mathrm{t2}} - p_{\mathrm{t1}} \tag{7}$$

NOTE 3 ACU pressure is expressed in pascals.

3.1.21
ACU static pressure
p_{sACU}
conventional quantity defined as the ACU pressure minus the ACU dynamic pressure corrected by the Mach factor

NOTE 1 This is determined using Equation (8):

$$p_{\mathrm{sACU}} = -p_{\mathrm{sg1}} \tag{8}$$

NOTE 2 ACU static pressure is expressed in pascals.

3.1.22
average outlet air velocity
v_{a}
airflow rate produced by the ACU divided by the cross-sectional area of the discharge nozzle plane at free-air delivery

NOTE See 4.4.3 for calculation of the value.

3.1.23
outlet air velocity uniformity
u_{ACU}
indicator of the consistency of air velocities across the air curtain width

NOTE 1 See 5.4.4 for calculation of the value. See Figure 7.

NOTE 2 The outlet air velocity uniformity is expressed as a percentage.

3.1.24
air curtain core velocity
v_{cx}
maximum air velocity of the air curtain at point x as measured across both the air curtain depth and width at specified distances from the discharge nozzle

NOTE See 5.1.1 and 5.3.4.

3.1.25
air curtain average core velocity
v_{ca}
average of air curtain core velocities measured along the air curtain width at specified distances from the discharge nozzle

NOTE See 6.4.3.

3.1.26
air curtain velocity projection
set of average air curtain core velocities measured along the air curtain width at specified distances from the discharge nozzle

NOTE 1 See 6.3.2.5.

NOTE 2 Velocity is expressed in metres per second.

3.1.27
motor input power
P_e
electrical power supplied at the terminals of an electric motor drive

NOTE Motor input power is expressed in watts.

3.1.28
ACU energy effectiveness
E_{ACU}
ratio described by the difference in energy loss through an opening without and with the use of an air curtain divided by the energy loss without the air curtain

NOTE The energy loss with the use of the air curtain includes the energy consumption of the air curtain

3.1.29
ACU fan efficiency
η_{fan}
ratio of the air power of the ACU to the motor input power of the ACU

3.1.30
ACU target distance
l_t
distance perpendicular to the discharge nozzle depth in metres, determined by the sponsor of the test, for the purpose of setting up the test

3.1.31
air power of ACU
P_{ACU}
conventional output power which is the product of the inlet volume flow rate, q_{Vsg1}, and the ACU pressure, p_{ACU}

NOTE 1 This is determined using Equation (9):

$$P_{ACU} = q_{Vsg1} \times p_{ACU} \tag{9}$$

NOTE 2 The air power of the ACU is expressed in watts when q_{Vsg1} is in cubic metres per second and p_{ACU} is in pascals.

3.1.32
point of operation
relative position on the air curtain performance curve corresponding to a particular airflow rate, pressure, power and efficiency

3.1.33
free-air delivery
that point of operation where the ACU operates against zero static pressure

3.1.34
determination
complete set of measurements for a particular point of operation for the parameter being determined

3.1.35
test
series of determinations of various characteristics at a single point of operation of an ACU

3.2 Symbols

Symbol	Term	Unit
A_n	Nozzle cross-sectional area	m^2
b_n	Air discharge nozzle width	mm
C_d	The calculated test line spacing	mm
E_{ACU}	ACU energy effectiveness	1
h_n	air discharge nozzle depth	mm
l_t	ACU target distance	m
η_{fan}	ACU fan efficiency	per unit
n	Number of data points	1

N	ACU speed (rotational)	r/min
p	Absolute pressure	Pa
p_{a}	Atmospheric pressure	Pa
p_{ACU}	ACU pressure	Pa
p_{d}	Dynamic pressure at a point	Pa
p_{e}	Gauge pressure	Pa
p_{esg}	Gauge stagnation pressure at a point	Pa
p_{sg}	Absolute stagnation pressure	Pa
p_{sg1}	Stagnation pressure at the ACU inlet	Pa
p_{sg2}	Stagnation pressure at the ACU outlet	Pa
p_{sACU}	ACU static pressure	Pa
P_{e}	Motor input power	W
P_{ACU}	Air power of ACU	W
q	ACU airflow rate	m^3/s
q_{m}	Mass flow rate	kg/s
q_{Vsg1}	Inlet stagnation volume flow rate	m^3/s
ρ_{a}	Air density	kg/m^3
ρ_{sg1}	Inlet stagnation density	kg/m^3
s	Standard deviation	1
θ	Air discharge angle	degrees
T_{d}	Dry-bulb temperature	°C
T_{w}	Wet-bulb temperature	°C
u_{ACU}	Outlet air velocity uniformity	%
v	Velocity	m/s
v_{a}	Velocity, average outlet	m/s
v_{ca}	Velocity, average (air curtain core)	m/s
v_{cx}	Velocity, air curtain core, at section x	m/s

4 Air curtain airflow rate test

4.1 Apparatus and instruments

4.1.1 General

Instruments and methods of measurement shall be in compliance with ISO 5801, except where specifically noted.

4.1.2 Power

Power shall be measured with the following.

4.1.2.1 **Wattmeter**, having a certified accuracy of ± 1 % of the observed reading.

4.2 Preparation of air curtain airflow rate test

The ACU shall be mounted with its inlet sealed to the test chamber in compliance with the requirements of Figure 1 a). The seal shall be adequate enough to minimize leakage. The air discharge nozzle or adjustable vanes in the air discharge nozzle shall be set to 0° ± 3°. Additional tests may be run at discharge angles other than 0°.

4.3 Test procedure

4.3.1 Initial conditions

The unit under test shall be energized and operated for not less than 15 min to allow equilibrium conditions to become established before the first determination. If the unit is equipped with a heating and/or cooling accessory (i.e. hydronic coil, electric coil and gas furnace), it shall be attached as catalogued. The accessory shall not be powered or activated during any part of the test unless it contributes to the active generation of airflow. In such cases, only the fan section(s) shall be energized.

4.3.2 Data to be recorded

4.3.2.1 ACU under test

The following information shall be recorded:

a) the initial conditions;

b) the name and address of the manufacturer;

c) the trade name;

d) the model number;

e) the impeller diameter;

f) the inlet and outlet areas;

g) the number of fans;

h) the air discharge angle;

i) the number of motors;

j) the data on the motor nameplate;

k) the accessories attached;

l) the accessories which are energized.

4.3.2.2 Test method

The description of the test method shall be recorded, including specific dimensions, as required by Figures 1, 3, 4 and 5. Alternatively, an annotated photograph of the arrangement shall be attached to the recorded data.

4.3.2.3 Apparatus and instruments

The apparatus and instruments used in the test shall be listed. Names, model numbers, serial numbers, scale ranges and calibration information shall be recorded.

4.3.2.4 Initial and final conditions

Initial and final readings of ambient dry-bulb temperature, T_d, ambient wet-bulb temperature, T_w and atmospheric pressure, p_a, shall be recorded for each determination.

4.3.3 Airflow rate determination

To establish the airflow rate at free-air delivery, a minimum of three determinations shall be taken at chamber gauge stagnation pressures ranging from +25 Pa to –25 Pa. If a chamber gauge stagnation pressure of –25 Pa cannot be obtained, then the lowest obtainable gauge stagnation pressure shall be used as the lower limit and the negative of this value shall be considered the upper limit. Plans shall be made to vary the chamber throttling device such that the test points will be well-spaced in terms of pressure. Approximately half of these determinations shall be taken at a positive pressure and the other half at a negative pressure.

4.4 Calculation

4.4.1 General

Calculations, except as noted in this subclause, shall be in compliance with the requirements of ISO 5801.

4.4.2 Static pressure as a function of airflow rate

The relationship between air curtain static pressure and air curtain airflow rate, for the range of static pressure tested, is represented by the second order polynomial in Equation (13):

$$p_{\text{esg1}} = p_{\text{esg3}} \tag{10}$$

$$p_{\text{sACU}} = -p_{\text{esg1}} \tag{11}$$

$$q = q_{\text{Vsg1}} \tag{12}$$

Where the coefficients K_2, K_1 and K_0 are derived from Equations (14), (15), (16), (17), (18), (19), (20), (21), (22), (23), (24) and (25):

$$p_{\text{sACU}} = K_2 q^2 + K_1 q + K_0 \tag{13}$$

$$a_0 = n \tag{14}$$

$$a_1 = \sum_{i=1}^{n} q_\mathrm{i} \tag{15}$$

$$a_2 = \sum_{i=1}^{n} q_\mathrm{i}^2 \tag{16}$$

$$a_3 = \sum_{i=1}^{n} q_\mathrm{i}^3 \tag{17}$$

$$a_4 = \sum_{i=1}^{n} q_\mathrm{i}^4 \tag{18}$$

$$b_0 = \sum_{i=1}^{n} p_\mathrm{sACUi} \tag{19}$$

$$b_1 = \sum_{i=1}^{n} (q_\mathrm{i} p_\mathrm{sACUi}) \tag{20}$$

$$b_2 = \sum_{i=1}^{n} (q_\mathrm{i}^2 p_\mathrm{sACUi}) \tag{21}$$

$$G = a_4 a_2 a_0 - a_4 a_1^2 - a_3^2 a_0 + 2 a_3 a_2 a_1 - a_2^3 \tag{22}$$

$$K_2 = \left(\frac{1}{G}\right)\left(a_2 a_0 b_2 - a_1^2 b_2 - a_3 a_0 b_1 + a_2 a_1 b_1 + a_3 a_1 b_0 - a_2^2 b_0\right) \tag{23}$$

$$K_1 = -\left(\frac{1}{G}\right)\left(a_3 a_0 b_2 - a_2 a_1 b_2 - a_4 a_0 b_1 + a_2^2 b_1 + a_4 a_1 b_0 - a_3 a_2 b_0\right) \tag{24}$$

$$K_0 = \left(\frac{1}{G}\right)\left(a_3 a_1 b_2 - a_2^2 b_2 - a_4 a_1 b_1 + a_3 a_2 b_1 + a_4 a_2 b_0 - a_3^2 b_0\right) \tag{25}$$

The value for K_2 shall be negative, indicating that the static pressure vs. airflow curve is concave inward. If K_2 is positive, then additional determinations should be selected in such a way as to broaden the range of static pressure for which airflow is determined.

Figure 2 graphically shows the curve defined by Equation (13). The free air point of operation is the point where the curve intersects the X-axis (p_sACU = 0).

Mathematically, the air curtain airflow rate at free delivery, q, is calculated using Equation (26):

$$q = \frac{-K_1 - \sqrt{K_1^2 - 4 K_0 K_2}}{2 K_2} \tag{26}$$

4.4.3 Average outlet air velocity

The average outlet air velocity, v_a, shall be the unit airflow rate divided by the cross-sectional area of the discharge nozzle plane, determined using Equation (27):

$$v_a = \frac{q}{A_n} \tag{27}$$

4.4.4 Air power of air curtain

The air power of an ACU is calculated using the values p_{ACU} and q from an airflow rate test conducted in accordance with ISO 5801. This is calculated using Equation (28):

$$P_{ACU} = q \times p_{ACU} \tag{28}$$

4.4.5 Power input to motor

The power input to the motor is determined from the value of P_e corresponding to the value of q used in 4.4.4.

4.4.6 Fan energy efficiency

Fan energy efficiency, η_{fan}, is determined using Equation (29):

$$\eta_{fan} = \frac{P_{ACU}}{P_e} \tag{29}$$

Fan energy efficiency is of less importance than ACU energy effectiveness due to the fact that the reduction of energy loss by an air curtain is much more than the energy input to the air curtain.

4.5 Test report

The test report shall be presented in consistent units. The test report shall contain the following information:

a) the name and address of the manufacturer;

b) the trade name;

c) the model number;

d) the impeller diameter;

e) the inlet and outlet areas;

f) the number of fans;

g) the number of motors;

h) the data on the motor nameplate.

The ACU airflow rate shall be presented graphically as shown in Figure 6.

In addition, the report shall be in compliance with ISO 5801.

5 Outlet air velocity uniformity test

5.1 Apparatus and instruments

Instruments and methods of measurement shall be in compliance with ISO 5801, except where specifically noted.

5.1.1 Air curtain core velocity measurement

Air curtain core velocity, v_{cx}, shall be measured with either of the following.

5.1.1.1 Pitot-static tube and manometer.

5.1.1.2 Hot-wire anemometer, or any other device reading to an accuracy of ± 5,0 % of the air velocity being measured. See 5.3.2.

5.2 Air velocity projection and outlet air velocity uniformity test

The ACU shall be placed in the testing area in compliance with the requirements of Figure 3 so that the inlet and outlet are unrestricted and the air curtain width is perpendicular to the floor. The air discharge nozzle or adjustable vanes in the air discharge nozzle shall be set to 0° ± 3°. Units shall be mounted so that nothing interferes with the airstream. Additional tests may be run at discharge angles other than 0°.

5.3 Test procedure

5.3.1 Initial conditions

The unit under test shall be energized and operated for not less than 15 min to allow equilibrium conditions to become established before the first determination. If the unit is equipped with a heating and/or cooling accessory (i.e. hydronic coil, electric coil or gas furnace), it shall be attached as catalogued. The accessory shall not be powered or activated during any part of the test unless it contributes to the active generation of airflow. In such cases, only the fan section(s) shall be energized.

5.3.2 Data to be recorded

5.3.2.1 ACU under test

The following information shall be recorded:

a) the initial conditions;

b) the name and address of the manufacturer;

c) the trade name;

d) the model number;

e) the impeller diameter;

f) the inlet and outlet areas;

g) the number of fans;

h) the air discharge angle;

i) the number of motors;

j) the data on the motor nameplate;

k) the accessories attached;

l) the accessories which are energized.

5.3.2.2 Test method

The description of the test method shall be recorded, including specific dimensions as required by Figures 1, 3, 4 and 5. Alternatively, an annotated photograph of the arrangement shall be attached to the recorded data.

5.3.2.3 Apparatus and instruments

The apparatus and instruments used in the test shall be listed. Names, model numbers, serial numbers, scale ranges and calibration information shall be recorded.

5.3.2.4 Initial and final conditions

Initial and final readings of ambient dry-bulb temperature, T_{d}, ambient wet-bulb temperature, T_{w}, and atmospheric pressure, p_{a}, shall be recorded for each determination.

5.3.3 Outlet air velocity uniformity test

The outlet air velocity uniformity test shall be based on air curtain core velocity, v_{cx}, measurements taken on a minimum of five equally spaced test lines on Plane 1 located one air discharge nozzle depth away from, and parallel to, the air discharge nozzle width. The test line locations at the two ends of the plane shall be one air discharge nozzle depth in from each end as shown in Figure 4. The remaining test line locations shall be equally spaced and each space shall not exceed 100 mm. Record the maximum air curtain core velocity readings along each test line within the plane. See Figure 7.

5.3.4 Air curtain core velocity

The maximum air curtain core velocities, v_{cx}, of the airstream shall be obtained by traversing each test line x, as shown in Figure 4 and recording each maximum reading using the instruments given in 5.1.1.

5.4 Calculation

5.4.1 General

Calculations, except as noted in this subclause, shall be in compliance with the requirements of ISO 5801.

5.4.2 Standard deviation

The standard deviation, s, is determined using Equation (30):

$$s = \sqrt{\frac{\sum\left(v_{\text{cx}}\right)^2 - \left(\frac{\left[\sum v_{\text{cx}}\right]^2}{n}\right)}{n-1}} \tag{30}$$

where n is the number of test points.

5.4.3 Average air curtain core velocity

The average air curtain core velocity, v_{ca}, is determined using Equation (31):

$$v_{\text{ca}} = \frac{\sum v_{\text{cx}}}{n} \tag{31}$$

5.4.4 Outlet air velocity uniformity

The outlet air velocity uniformity, u_{ACU}, of the ACU shall be expressed as a percentage calculated from the average air curtain core velocity, v_{ca}, and standard deviation, s, of Plane 1, Figure 4, using Equation (32). Other test planes may be stipulated for the calculation of outlet air velocity uniformity.

$$u_{\text{ACU}} = 100 - \left(\frac{100s}{v_{\text{ca}}} \right) \% \tag{32}$$

See example in Figure 7.

5.5 Test report

The test report shall be presented in consistent units. The test report shall contain the following information:

a) the name and address of the manufacturer;

b) the trade name;

c) the model number;

d) the impeller diameter;

e) the inlet and outlet areas;

f) the number of fans;

g) the number of motors;

h) the motor nameplate data.

The locations and the results of the measurements shall be presented in a table with the calculated arithmetic average of the measured results, their standard deviation and uniformity, as shown in Figure 7.

6 Air curtain velocity projection test

6.1 Apparatus and instruments

Instruments and methods of measurement shall be in compliance with ISO 5801, except where specifically noted.

6.1.1 Air curtain core velocity measurement

Air curtain core velocity, v_{cx}, shall be measured with either of the following.

6.1.1.1 Pitot-static tube and manometer.

6.1.1.2 Hot-wire anemometer, or any other device with an accuracy of ± 5,0 % of the air velocity being measured. See 6.3.2.

6.2 Equipment and organization

The ACU shall be placed in the testing area in compliance with the requirements of Figure 3 so that the inlet and outlet are unrestricted and the air curtain width is perpendicular to the floor. The air discharge nozzle or adjustable vanes in the air discharge nozzle shall be set to 0° ± 3°. Units shall be mounted so that nothing interferes with the airstream. Additional tests may be run at discharge angles other than 0°.

6.3 Test procedure

6.3.1 Initial conditions

The unit under test shall be energized and operated for not less than 15 min to allow equilibrium conditions to become established before the first determination. If the unit is equipped with a heating and/or cooling accessory (i.e. hydronic coil, electric coil or gas furnace), it shall be attached as catalogued. The accessory shall not be powered or activated during any part of the test unless it contributes to the active generation of airflow. In such cases, only the fan section(s) shall be energized.

6.3.2 Data to be recorded

6.3.2.1 ACU under test

The following information shall be recorded:

a) the initial conditions;

b) the name and address of the manufacturer;

c) the trade name;

d) the model number;

e) the impeller diameter;

f) the inlet and outlet areas,

g) the number of fans;

h) the air discharge angle;

i) the number of motors;

j) the data on the motor nameplate;

k) the accessories attached;

l) the accessories which are energized.

6.3.2.2 Test method

The description of the test method shall be recorded, including specific dimensions as required by Figures 1, 3, 4 and 5. Alternatively, an annotated photograph of the arrangement shall be attached to the recorded data.

6.3.2.3 Apparatus and instruments

The apparatus and instruments used in the test shall be listed. Names, model numbers, serial numbers, scale ranges and calibration information shall be recorded.

6.3.2.4 Initial and final conditions

Initial and final readings of ambient dry-bulb temperature, T_{d}, ambient wet-bulb temperature, T_{w}, and atmospheric pressure, p_{a}, shall be recorded for each determination.

6.3.2.5 Air curtain velocity projection test

The air curtain velocity projection test shall be based on air curtain core velocity measurements taken on a minimum of three planes parallel to the plane of the air discharge nozzle as shown in Figure 5. The air curtain core velocities shall be recorded on a minimum of five equally spaced test lines across each plane. The test line locations at the two ends of each plane shall be located one air discharge nozzle depth in from each end as shown in Figure 5. The remaining test line locations shall be equally spaced and each space shall not exceed 100 mm. Record the maximum air curtain air core velocity reading along the test lines within each plane.

The sponsor of the test shall determine the number of test planes by specifying an ACU target distance, l_t.

The ACU target distance shall be a minimum of 1 000 mm, or whole multiples thereof. Additional tests may be run at ACU target distances that are not a multiple of 1 000 mm.

For an ACU target distance greater than or equal to 3 000 mm, the air curtain core velocities shall be measured at Plane 2 (1 000 mm), Plane 3 (2 000 mm) and Plane 4 (3 000 mm). Additional readings shall be taken at consecutively numbered planes located at 1 000 mm intervals until the ACU target distance is reached.

For an ACU target distance of 2 000 mm, the air curtain core velocity shall be measured at Plane 2 (1 000 mm), Plane 2A (1 500 mm) and Plane 3 (2 000 mm).

For an ACU target distance of 1 000 mm, the air curtain core velocity shall be measured at Plane 1A (500 mm), Plane 2 (1 000 mm) and Plane 2A (1 500 mm).

6.4 Calculation

6.4.1 General

Calculations, except as noted in this clause, shall be in compliance with the requirements of ISO 5801.

6.4.2 Air curtain core velocity

The maximum air curtain core velocities, v_{cx}, of the airstream shall be obtained by traversing each test line x, as shown in Figure 4 and recording each maximum reading using the instruments given in 6.1.1.

6.4.3 Air curtain average core velocity

The air curtain average core velocity, v_{ca}, is determined using Equation (34):

$$v_{ca} = \frac{\sum v_{cx}}{n} \tag{33}$$

6.4.4 Air curtain velocity projection

The air curtain velocity projection shall be the average air curtain core velocities, v_{ca}, determined using Equation (31), for each test plane defined in 6.3.2.5. See example in Figure 7.

6.5 Test report

The test report shall be presented in consistent units. The test report shall contain the following information:

a) the name and address of the manufacturer;

b) the trade name;

c) the model number;

d) the impeller diameter;

e) the inlet and outlet areas;

f) the number of fans;

g) the number of motors;

h) the data on the motor nameplate.

The locations and the results of the measurements shall be presented in a table with the calculated arithmetic average of the measured results, their standard deviation and uniformity for each distance from the air discharge nozzle, as shown in Figure 7.

7 Illustration of tests

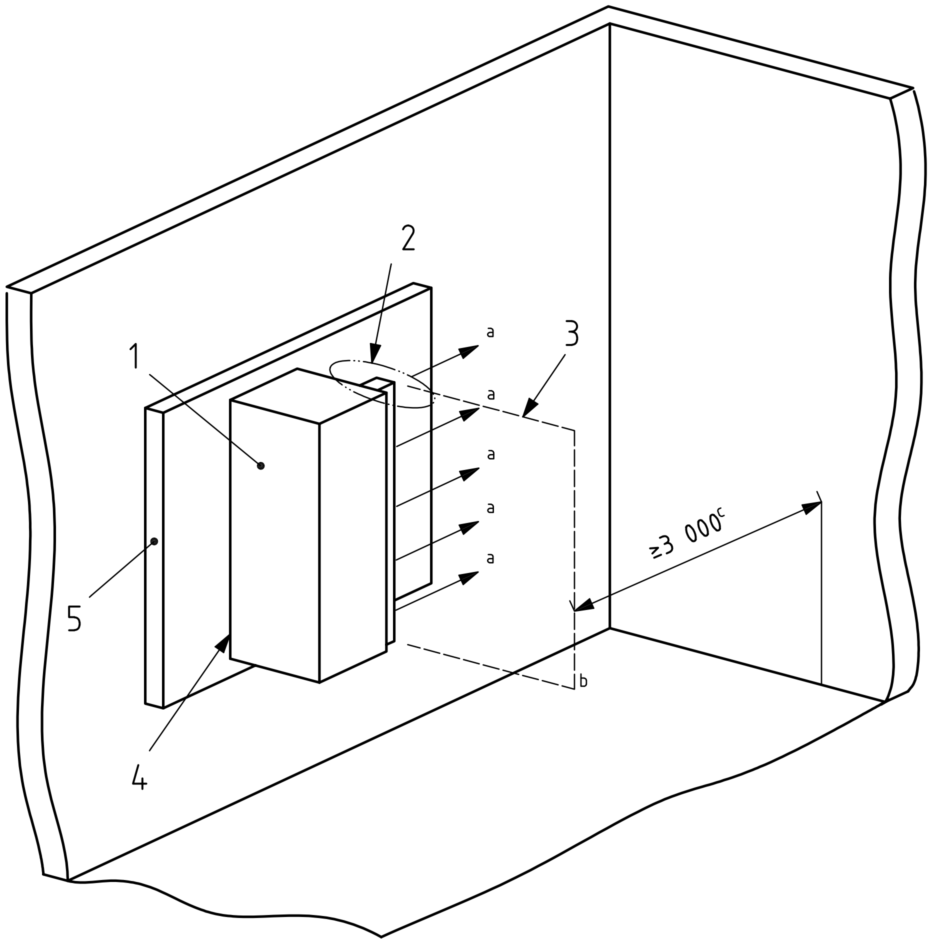
7.1 Airflow and pressure measurements shall be made in accordance with Clauses 4, 5 and 6; calculations shall be made in accordance with ISO 5801.

If an ACU has multiple inlets, it shall be mounted so that all of the inlets are contained within the testing chamber.

NOTE 1 The unit can be mounted horizontally or vertically.

NOTE 2 Air discharge nozzle angle is arranged as given in Figure 1 b).

Dimensions in millimetres



Key

1 ACU

2 air discharge nozzle angle arrangement [as given in Figure 1 b)]

3 plane

4 ACU inlet sealed to testing chamber

5 testing chamber

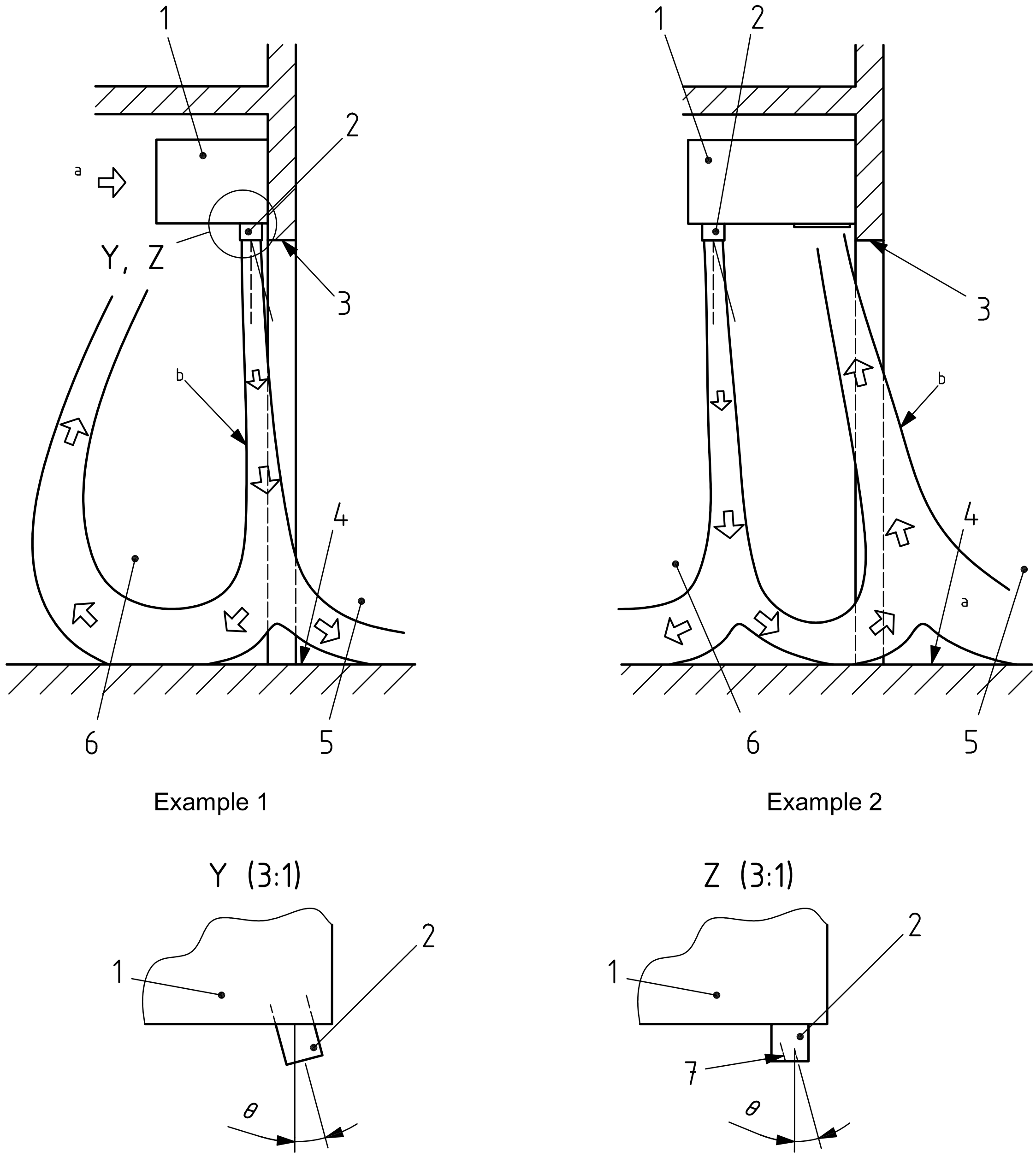
a Air flow.

b ISO 5801 (air discharge nozzle plane).

c Minimum clearance.

a) Airflow rate test method

Figure 1 (*continued*)



1 ACU
2 air discharge nozzle
3 top of side of opening
4 floor or side of opening
5 outside (unconditioned or contaminated area)
6 inside (conditioned or protected area)
7 adjustable vanes
θ air discharge angle
[a] Air flow.
[b] Air stream.

b) Air discharge nozzle angle method

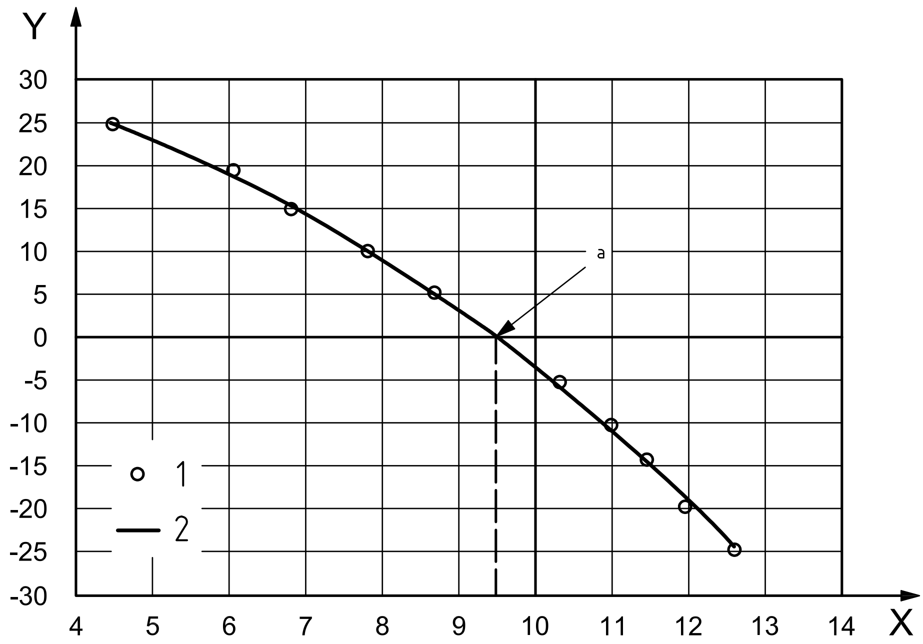
Figure 1 — Airflow rate and angle method

7.2 In determining the air discharge angle, θ, the orientation of the ACU shall be established by the ACU's normal application mounting position.

Units shall be mounted so that nothing interferes with the airstream.

NOTE The examples in Figure 1 are not intended to represent every possible ACU mounting application; they are only examples of how the direction of q is determined.

For example the nozzle arrangement of an ACU designed for outdoor application (not shown) shall be determined by the definition and the guidelines illustrated in the two examples in Figure 1. Following these criteria yields the direction of q to be the same as that shown in Example 2 (opposite that shown in Detail A and Detail B).



Key

X Airflow q (m^3/s)

Y p_{sACUi} static pressure (Pa)

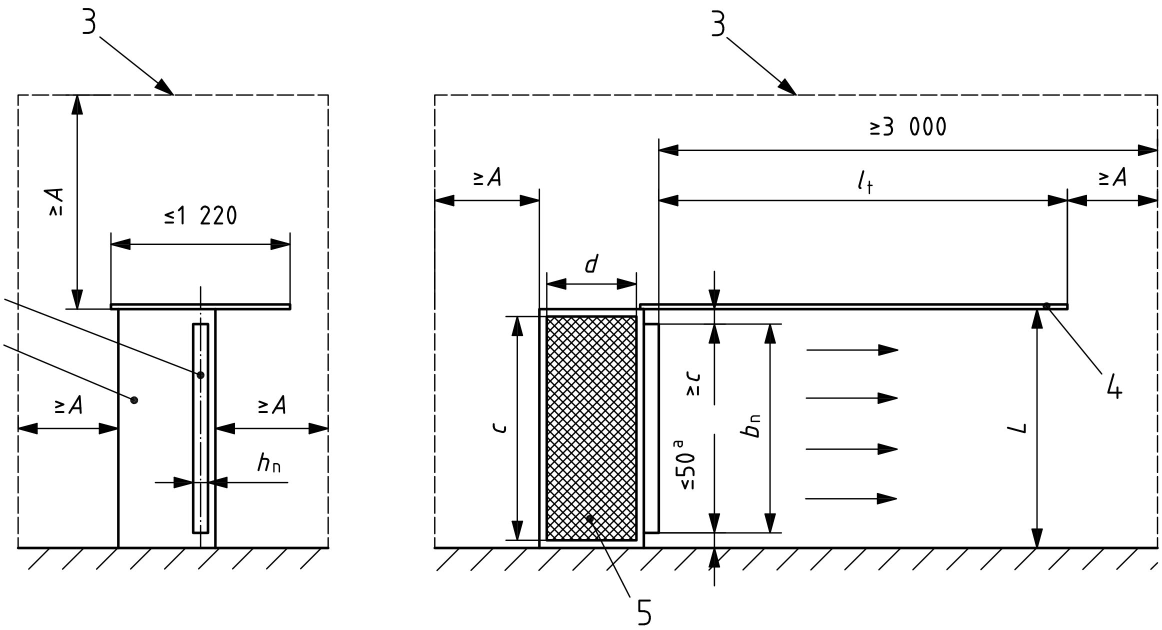
1 p_{sACUi}

2 $p_{sACU} = K_2q^2 + K_1q + K_0$

a Free air ($p_{sACUi} = 0$).

Figure 2 — Airflow vs. static pressure curve

Dimensions in millimetres



Key

1 ACU

2 air discharge nozzle

3 room walls

4 top baffle

5 ACU inlet

A two equivalent ACU diameters (see 7.3)

l_t ACU target distance

[a] Maximum; if floor to nozzle or top baffle to nozzle clearance is greater than 50 mm, add a bottom baffle or adjust the position of the top baffle to close the distance.

Figure 3 — Outlet air velocity uniformity and air velocity projection test method

7.3 A, which is equal to two equivalent ACU inlet diameters, is determined using Equation (34):

$$A = 4\sqrt{\frac{C_d}{\pi}} \tag{34}$$

For ACUs without a rectangular inlet, substitute the actual value of the inlet area for C_d in Equation (34).

For ACUs with multiple inlets, substitute the sum of all inlet areas for C_d in Equation (34).

NOTE 1 See Figures 4 and 5 for test plane locations.

NOTE 2 The air discharge nozzle angle is arranged as given in Figure 1 b).

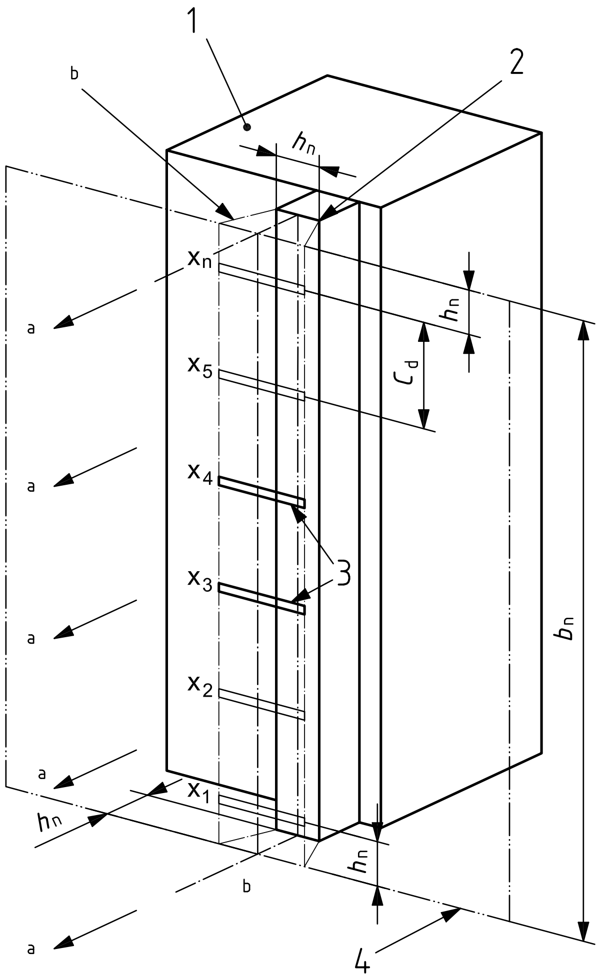
NOTE 3 Centre baffle(s) is/are over centreline of airflow.

NOTE 4 h_n is the air discharge nozzle depth.

NOTE 5 b_n is the air discharge nozzle width.

If an ACU has multiple inlets, the nearest surface to each inlet (including the floor) shall be equal to the A value of that inlet. If an ACU has to be suspended above the floor, a bottom baffle identical to the top baffle shall be used.

Dimensions in millimetres



Key

1 ACU

2 air discharge nozzle

3 test lines

4 plane 1

b_n air discharge nozzle width

C_d test line spacing

h_n air discharge nozzle depth

[a] Air flow.

[b] Air stream.

Figure 4 — Outlet air velocity uniformity test method

7.4 Test line spacing, C_d, is calculated using Equation (35):

$$C_d = \frac{b_n - 2h_n}{n-1} \leqslant 100 \text{ mm} \qquad (35)$$

where n is the number of test lines, x (5 min.).

The calculated test line spacing, C_d, shall be less than or equal to 100 mm and rounded to the nearest multiple of 5 mm.

7.5 The air curtain average core velocity, v_{ca}, is determined using Equation (36):

$$v_{ca} = \frac{\sum(v_{cx})}{n} \tag{36}$$

where

v_{cx} is the core (peak) air velocity along test line x;

n is the number of test lines, x (5 min.).

7.6 The standard deviation, s, is determined using Equation (37):

$$s = \sqrt{\frac{\sum(v_{cx})^2 - \left(\frac{\left[\sum(v_{cx})\right]^2}{n}\right)}{n-1}} \tag{37}$$

where

n is the number of test lines, x (5 min.);

v_{cx} is the core (peak) air velocity along test line x.

NOTE 1 The ACU is arranged as given in Figure 3.

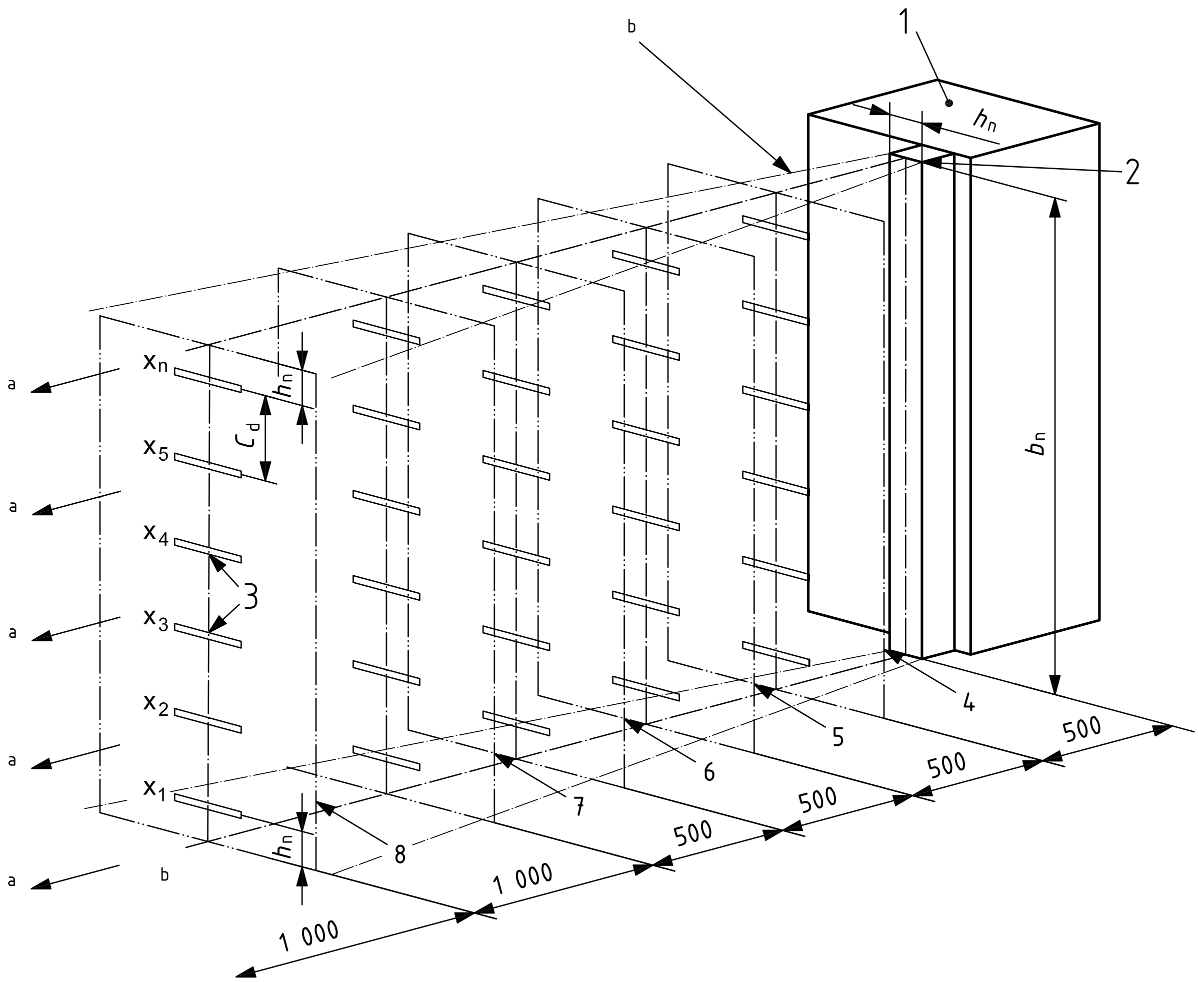
NOTE 2 The air discharge nozzle angle is arranged as given in Figure 1 b).

NOTE 3 h_n is the air discharge nozzle depth.

NOTE 4 b_n is the air discharge nozzle width.

NOTE 5 v_{cx} is the core (peak) air velocity along test line x.

Dimensions in millimetres



Key

1 ACU

2 air discharge nozzle

3 test lines (typ)

4 plane 1A

5 plane 2

6 plane 2A

7 plane 3

8 additional plane(s) 4, 5, etc.

[a] Air flow.

[b] Air stream.

Figure 5 — Air velocity projection test method

7.7 The internal test line spacing, C_d, is determined using Equation (38):

$$C_d = \frac{b_n - 2h_n}{n-1} \leqslant 100 \text{ mm} \tag{38}$$

where n is the number of test lines, x (5 min.).

The calculated test line spacing, C_d, shall be less than or equal to 100 mm and rounded to the nearest multiple of 5 mm.

7.8 The air curtain average core velocity, v_{ca}, is determined using Equation (39):

$$v_{ca} = \frac{\sum(v_{cx})}{n} \tag{39}$$

where

v_{cx} is the core (peak) air velocity along test line x;

n is the number of test lines, x (5 min).

7.9 The standard deviation, s, is determined using Equation (40):

$$s = \sqrt{\frac{\sum(v_{cx})^2 - \left(\frac{\left[\sum v_{cx}\right]^2}{n}\right)}{n-1}} \tag{40}$$

where

v_{cx} is the core (peak) air velocity along test line x;

n is the number of test lines, x (5 min.).

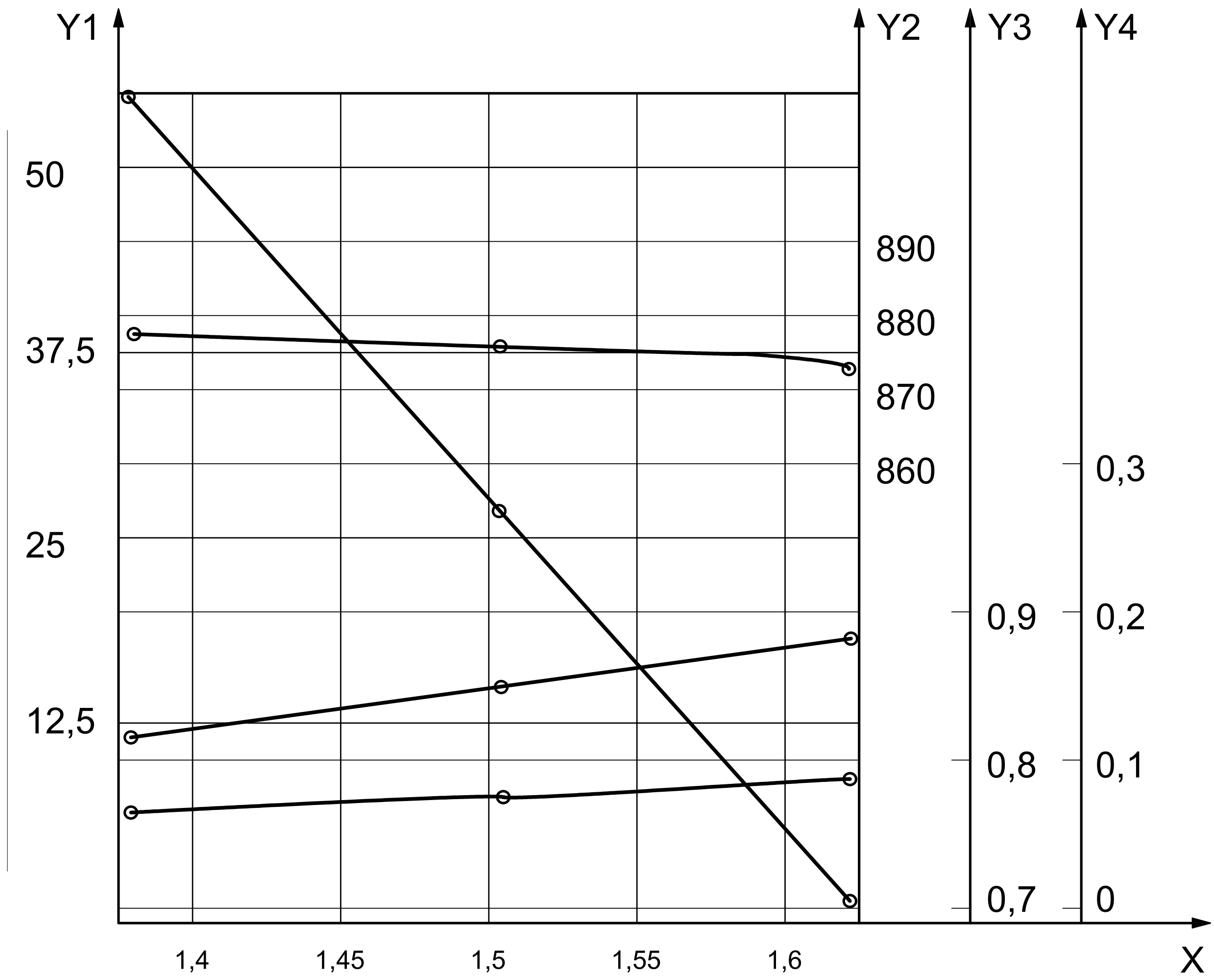
Plane locations shall be accurate to ± 25 mm. Additional planes shall be spaced every 1 000 mm.

NOTE 1 The ACU is arranged as given in Figure 3.

NOTE 2 The air discharge nozzle angle is arranged as given in Figure 1 b).

NOTE 3 h_n is the air discharge nozzle depth.

NOTE 4 b_n is the air discharge nozzle width.



Key

X ACU airflow rate, expressed in cubic metres per second

Y1 static pressure, expressed in pascals

Y2 Fan speed, in revolutions per minute.

Y3 Power input, in kilowatts.

Y4 Efficiency, per unit.

Figure 6 — Typical ACU airflow rate performance chart

Manufacturer:	XYZ Inc.	Test no.	97733-1A
Air curtain model:	ABC	Test date:	7/22/97
		by:	SWS / DAJ

h_n	102	mm	b_n	1 219	mm
T_d	22,2	°C	T_w	17,8	°C

Atmospheric pressure:	96 685	Pa	Laboratory:	DEF
Air density:	1,113	kg/m^3	Location:	GHI

ISO 27327-1

Test line		**Plane 1**		**Plane 2**		**Plane 3**		**Plane 4**	
	Distance	100	mm	1 000	mm	2 000	mm	3 000	mm
no.	mm from floor	p_v Pa	v_{cx} m/s	p_v Pa	v_{cx} m/s	p_v Pa	v_{cx} m/s	p_v Pa	v_{cx} m/s
1	100,00	178	17,7	28,9	7,14	22,4	6,29	13,7	4,92
2	200,00	159	16,7	24,9	6,63	20,4	6,00	14,9	5,14
3	300,00	274	22,0	37,4	8,13	27,4	6,95	16,2	5,35
4	400,00	224	19,9	41,8	8,59	32,1	7,53	19,4	5,86
5	500,00	155	16,6	44,6	8,87	33,4	7,68	21,2	6,11
6	600,00	126	14,9	58,3	10,14	49,6	9,35	28,6	7,11
7	700,00	155	16,6	45,3	8,94	33,1	7,65	24,4	6,56
8	800,00	209	19,2	42,6	8,67	31,4	7,44	21,4	6,15
9	900,00	349	24,8	36,9	8,07	28,6	7,11	19,9	5,93
10	1 000,00	163	17,0	24,4	6,56	21,4	6,15	15,2	5,18
11	1 100,00	174	17,5	25,9	6,76	21,9	6,22	14,2	5,01
12									
13									
14									
15									
16									
17									
18									
19									
20									
Air curtain average core velocity, v_{ca}		18,45 m/s		8,05 m/s		7,13 m/s		5,76 m/s	
Standard deviation, s		2,86 m/s		1,15 m/s		0,98 m/s		0,70 m/s	
Outlet air velocity uniformity, u_{ACU}		85%		—		—		—	

Figure 7 — Sample outlet air velocity uniformity and air velocity projection calculations

Annex A
(normative)

Uncertainty in velocity determination using Pitot-static tube and manometer

The values given in Table A.1 are based on an error equivalent to an indicating column length of 12 Pa in a vertical manometer having a 1:1 slope ratio.

Table A.1 — Table of 5 percent uncertainty

Slope ratio	Minimum usable velocity
1:1	14 m/s
2:1	10 m/s
5:1	6 m/s
10:1	5 m/s
20:1	3 m/s
Source: David Johnson, Berner International Corporation, 1998.	

Bibliography

[1] ASME Steam Tables, *American Society of Mechanical Engineers*, New York, NY, AMCA No. 2312, 1967, p. 283

ICS 23.120

Price based on 29 pages