

AS/NZS 5801:2024



Australian/New Zealand Standard™

Fans — Performance testing using standardized airways (ISO 5801:2017, MOD)



AS/NZS 5801:2024

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Airconditioning and Refrigeration Equipment Manufacturers Association
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Australian Institute of Refrigeration Air Conditioning and Heating
Bureau of Steel Manufacturers of Australia Limited
Energy Efficiency & Conservation Authority of New Zealand
Engineers Australia
Fan Manufacturers Association of Australia and New Zealand

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Australian/New Zealand Standard™

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Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-013, Industrial Fans, to supersede AS ISO 5801:2004.

The objective of this document is to specify procedures for the determination of the performance of fans of all types except those designed solely for air circulation, e.g. ceiling fans and table fans. Testing of jet fans is described in ISO 13350.

This document is an adoption with national modifications, and has been reproduced from ISO 5801:2017, *Fans — Performance testing using standardized airways*.

The modifications are additional requirements and are set out in [Appendix ZZ](#) which has been added at the end of the source text. [Appendix ZZ](#) lists the modifications to ISO 5801:2017 for the application of this document in Australia and New Zealand.

As this document has been reproduced from an international document, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 117, *Fans*.

This third edition cancels and replaces the second edition (ISO 5801:2007), which has been technically revised. It also incorporates the Technical Corrigendum ISO 5801:2007/Cor.1:2008.

Introduction

This document is the result of almost 50 years of discussion, comparative testing and detailed analyses by leading specialists from the fan industry and research organizations throughout the world.

It was demonstrated many years ago that the codes for fan performance testing established in different countries do not always lead to the same results.

The need for an International Standard has been evident for some time and Technical Committee ISO/TC 117 started its work in 1963. Important progress has been achieved over the years and, although the International Standard itself was not yet published, the successive revisions of various national standards led to much better agreement among them.

It has become possible since 1997 to complete this document by agreement on certain essential points. It is to be borne in mind that the test equipment, especially for large fans, is very expensive and it was necessary to include in this document many setups from various national codes in order to authorize their future use. This explains the sheer volume of the first edition (ISO 5801:1997).

The second edition (ISO 5801:2007) of this document was the result of a survey of ISO members, deleting those methods that were the least frequently used. A significant reduction in the number of pages had been achieved.

For the third edition, the contents were reorganized to define and allow all possible configurations of defined component parts as standardized test setups. A further significant reduction of volume has been achieved by streamlining the content.

Essential features of this document are as follows.

— **Installation categories and test configurations** (see [Clause 5](#) and [Clause 6](#)).

Since the connections of a duct to a fan inlet and/or outlet affect the fan's performance, a number of installation categories and test configurations need to be recognized.

— **Common segments** (see [Clause 8](#)).

It is essential that all standardized test airways to be used with fans need to have portions in common adjacent to the fan inlet and/or outlet sufficient to ensure consistent determination of fan pressure.

Geometric variations of these common segments are strictly limited.

— **Flow rate measurement** (see [12.5](#) and [Annex A](#)).

Determination of flow rate has been separated from the determination of fan pressure. A number of standardized methods may be used.

— **Test results** (see [Clause 15](#)).

Methods of measurement and calculation for the flow rate, for the fan pressure and for the fan efficiencies are established taking into account all compressibility effects of the air. For fan pressure less than 2 000 Pa, the change of density between fan inlet and fan outlet is allowed to be neglected. Other compressibility effects are allowed to be neglected for reference velocity values not higher than 65 m/s (see [Clause 13](#)).

Australian/New Zealand Standard

Fans — Performance testing using standardized airways (ISO 5801:2017, MOD)

1 Scope

This document specifies procedures for the determination of the performance of fans of all types except those designed solely for air circulation, e.g. ceiling fans and table fans. Testing of jet fans is described in ISO 13350.

This document provides estimates of uncertainty of measurement and rules for the conversion, within specified limits, of test results for changes in speed, gas handled and, in the case of model tests, size are given.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 5136, *Acoustics — Determination of sound power radiated into a duct by fans and other air-moving devices — In-duct method*

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

ISO 5802, *Industrial fans — Performance testing in situ*

ISO 13347 (all parts), *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions*

ISO 13348, *Industrial fans — Tolerances, methods of conversion and technical data presentation*

ISO 13349, *Fans — Vocabulary and definitions of categories*

ISO 13350, *Fans — Performance testing of jet fans*

IEC 60034-1:2010, *Rotating electrical machines — Part 1: Rating and performance*

IEC 60034-2-1:2014, *Rotating electrical machines — Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60051-2, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 2: Special requirements for ammeters and voltmeters*

IEC 60051-3, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 3: Special requirements for wattmeters and varmeters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13349 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1**air**

working fluid for tests with standardized airways shall be atmospheric air

3.2**standard air**

air (3.1) with a density of 1,2 kg/m³

Note 1 to entry: See 12.9.4.

3.3**upstream**

direction from where the air flow comes

3.4**downstream**

direction to where the air flow discharges

3.5**cross sectional area** **A**

area contained in a boundary

3.6**fan inlet area** **A_1**

cross sectional area (3.5) of fan inlet as defined in ISO 13349

3.7**fan outlet area** **A_2**

cross sectional area (3.5) of fan outlet as defined in ISO 13349

3.8**hydraulic diameter** **D_h**

four times the cross sectional area divided by the perimeter which encloses the area

$$D_h = \frac{4 \cdot A}{P_{\square}}$$

3.9**hydraulic mean depth** **H_h**

cross sectional area divided by the perimeter which encloses the area

$$H_h = \frac{A}{P_{\square}}$$

3.10**absolute temperature** **θ**

temperature expressed in Kelvin and calculated from the relative gas temperature in degree Celsius plus the thermodynamic temperature according to ISO 13349 of absolute zero

$$\theta = T + 273,15$$

3.11**absolute temperature of moving air** **θ**

absolute temperature (3.10) theoretically registered by a thermal sensor moving at the air velocity calculated from the formula

$$\theta = \frac{\theta_{sg}}{\left(1 + \frac{\kappa - 1}{2} \cdot Ma^2\right)}$$

or

$$\theta = \theta_{sg} - \frac{v^2}{2 \cdot c_p}$$

3.12**stagnation temperature** **θ_{sg}**

absolute temperature (3.10) measured at an isentropic stagnation point

Note 1 to entry: The stagnation temperature is constant along an airway without exchange of energy or heat.

3.13**specific heat at constant pressure** **c_p**

amount of heat energy required to raise the temperature of air per unit of mass at constant pressure

3.14**specific heat at constant volume** **c_V**

amount of heat energy required to raise the temperature of air per unit of mass at constant volume

3.15**isentropic exponent** **κ**

ratio of the specific heat at constant pressure to the specific heat at constant volume

$$\kappa = \frac{c_p}{c_V}$$

3.16**specific gas constant** **R**

difference between the specific heat at constant pressure versus the specific heat at constant volume

$$R = c_p - c_V$$

use

$$R = \frac{p}{\rho \cdot \theta}$$

where

ρ is the *air density* (3.18) (kg/m³)

p is the *absolute pressure* (3.27) (Pa)

θ is the *absolute temperature* (3.10) (K)

For dry air, $R_{\text{dry}} = 287.058 \text{ J}/(\text{kg}\cdot\text{K})$

3.17 specific gas constant for humid air

R_{wet}
atmospheric pressure divided by the density of air multiplied by the absolute ambient temperature

$$R_{\text{wet}} = \frac{p_a}{\rho \cdot \theta_a}$$

3.18 air density

ρ
air density calculated from the *absolute pressure*, p , (3.27) and the air temperature, θ

$$\rho = \frac{p}{R_{\text{wet}} \cdot \theta}$$

3.19 stagnation density

ρ_{sg}
air density (3.18) calculated from the *stagnation pressure*, p_{sg} , (3.29) and the *stagnation temperature*, θ_{sg} (3.12)

$$\rho_{\text{sg}} = \frac{p_{\text{sg}}}{R_{\text{wet}} \cdot \theta_{\text{sg}}}$$

3.20 mean density

ρ_{m}
mean value of the air densities of the fan

$$\rho_{\text{m}} = \frac{\rho_1 + \rho_2}{2}$$

3.21 mean stagnation density

ρ_{sgm}
mean value of the stagnation densities of the fan

$$\rho_{\text{sgm}} = \frac{\rho_{\text{sg1}} + \rho_{\text{sg2}}}{2}$$

3.22 mass flow rate

q_m
mean value, over time, of the mass of air which passes through the airway per unit of time

3.23 volume flow rate

qV_1
mass flow rate (3.22) divided by the density at fan inlet

$$qV_1 = \frac{q_m}{\rho_1}$$

3.24**volume flow rate at stagnation conditions** **q_{Vsg1}**

mass flow rate (3.22) divided by the stagnation density (3.19) at fan inlet

$$q_{Vsg1} = \frac{q_m}{\rho_{sg1}}$$

3.25**average velocity** **v**

mass volume flow rate divided by the cross sectional area multiplied by the air density

$$v = \frac{q_m}{\rho \cdot A}$$

3.26**reference velocity** **$v_{2.ref}$** velocity calculated at fan outlet, A_2 , for the maximum mass flow rate (3.22) of the fan, $q_{m,max}$, and for the reference density of standard air (3.2), $\rho_{ref} = 1,200 \text{ kg/m}^3$

$$v_{2.ref} = \frac{q_{m,max}}{\rho_{ref} \cdot A_2}$$

Note 1 to entry: See 12.9.3.

3.27**absolute pressure** **p**

pressure, measured with respect to absolute zero pressure

3.28**mean gauge pressure**differential pressure, measured with respect to ambient pressure $p_e = p - p_a$ **3.29****stagnation pressure** **p_{sg}**

absolute pressure (3.27), if the air were brought to rest via an isentropic process

$$p_{sg} = p \cdot \left(1 + \frac{\kappa - 1}{2} \cdot Ma^2 \right)^{\frac{\kappa}{\kappa - 1}} = p + f_M \cdot p_d$$

3.30**dynamic pressure** **p_d** pressure calculated from the velocity, v , and the density, ρ

$$p_d = \rho \cdot \frac{v^2}{2}$$

3.31**total pressure** **p_{tot}**

pressure calculated from the *absolute pressure* (3.27) and the *dynamic pressure* (3.30)

$$p_{\text{tot}} = p + p_d$$

3.32 fan dynamic pressure

p_{fd}
dynamic pressure (3.30) of the fan, defined at the fan outlet with the *average velocity* (3.25)

$$p_{fd} = p_{d2} = \rho_2 \cdot \frac{v_2^2}{2}$$

3.33 fan pressure

p_f
difference between the *stagnation pressures* (3.29) at the fan outlet and the fan inlet

$$p_f = p_{sg2} - p_{sg1}$$

or difference between the *total pressures* (3.31) at the fan outlet and the fan inlet

$$p_f = p_{\text{tot}2} - p_{\text{tot}1} \text{ allowed if } v_{2,\text{ref}} \leq 65 \text{ m/s}$$

Note 1 to entry: For the establishment of the value 65 m/s, see [Clause 13](#).

3.34 fan static pressure

p_{fs}
difference between the static pressure at the fan outlet and the *stagnation pressure* (3.29) at the fan inlet

$$p_{fs} = p_2 - p_{sg1} = p_{sg2} - p_{d2} \cdot f_{M2} - p_{sg1} = p_f - p_{fd} \cdot f_{M2}$$

or difference between the static pressure at the fan outlet and the *total pressure* (3.31) at the fan inlet

$$p_{fs} = p_2 - p_{\text{tot}1} = p_{\text{tot}2} - p_{d2} - p_{\text{tot}1} = p_f - p_{fd} \text{ allowed if } v_{2,\text{ref}} \leq 65 \text{ m/s}$$

Note 1 to entry: For the establishment of the value 65 m/s, see [Clause 13](#).

3.35 fan pressure ratio

r
ratio of the average absolute *stagnation pressure* (3.29) at the outlet section of a fan to that at its inlet section as given by the following formula

$$r = \frac{p_{sg2}}{p_{sg1}}$$

Note 1 to entry: The fan pressure ratio is dimensionless.

3.36 rotational frequency of the impeller

n
number of revolutions of the fan impeller per second

3.37**tip speed of the impeller** **u**

peripheral speed of the impeller blade tips

$$u = \pi \cdot n \cdot D_r$$

3.38**velocity of sound** **c** distance travelled per unit time by a sound wave as it propagates through air $c = \sqrt{\kappa \cdot R_{\text{wet}} \cdot \theta}$ **3.39****Mach number** **Ma** ratio of the air velocity to the *velocity of sound* (3.38)

$$Ma = \frac{v}{c}$$

3.40**peripheral Mach number** **Ma_u** ratio of tip speed to the *velocity of sound* (3.38) at the fan inlet stagnation conditions

$$Ma_u = \frac{u}{\sqrt{\kappa \cdot R_{\text{wet}} \cdot \theta_{\text{sg1}}}}$$

3.41**Mach factor** **f_M** correction factor applied to the *dynamic pressure* (3.30)

$$f_M = \frac{p_{\text{sg}} - p}{p_d}$$

Note 1 to entry: The Mach factor f_M may be calculated by:

$$f_M = 1 + \frac{Ma^2}{4} + \frac{(2-\kappa) \cdot Ma^4}{24} + \frac{(2-\kappa) \cdot (3-2\kappa) \cdot Ma^6}{192} + \dots$$

3.42**fan work per unit mass** **y_f**

increase in energy of air per unit mass passing through the fan

$$y_f = \frac{p_2 - p_1}{\rho_m} + \frac{1}{2} \cdot f_{M2} \cdot v_2^2 - \frac{1}{2} \cdot f_{M1} \cdot v_1^2$$

3.43**fan air power** **P_u** mass flow multiplied by the fan work per unit mass $P_u = q_m \cdot y_f = q_{V\text{sg1}} \cdot p_f \cdot k_p$

3.44 compressibility coefficient k_P

ratio of the compressible to the incompressible determination of the fan output power, of the air moved, for the same fan inlet air density, pressure ratio and *mass flow rate* ([3.22](#))

Note 1 to entry: The fan output power is derived on the assumption of polytropic compression with no heat transfer through the fan casing.

3.45 impeller power P_r

mechanical power supplied to the fan impeller

3.46 fan shaft power P_a

mechanical power supplied to the fan shaft

Note 1 to entry: Fan shaft power includes bearing losses, while fan *impeller power* ([3.45](#)) does not.

3.47 motor output power P_o

shaft power output of the motor or other prime mover

3.48 motor input power P_e

electrical input power supplied at the terminals of an electric motor drive without a variable speed drive

3.49 drive control electrical input power P_{ed}

electrical input power measured at the input terminals to the variable speed drive of a motor

3.50 fan impeller efficiency η_r

fan air power ([3.43](#)) divided by the *impeller power* ([3.45](#))

$$\eta_r = \frac{P_u}{P_r}$$

3.51 fan shaft efficiency η_a

fan air power ([3.43](#)) divided by the *fan shaft power* ([3.46](#))

$$\eta_a = \frac{P_u}{P_a}$$

3.52 fan motor shaft efficiency η_o

fan air power (3.43) divided by the *motor output power* (3.47)

$$\eta_o = \frac{P_u}{P_o}$$

Note 1 to entry: Differs from *fan shaft power* (3.46) by the amount of transmission losses because of the transmission losses.

3.53

overall efficiency for a fan without variable speed drive

η_e

fan air power (3.43) divided by the *motor input power* (3.48) for the fan without variable speed drive

$$\eta_e = \frac{P_u}{P_e}$$

3.54

overall efficiency for a fan with variable speed drive

η_{ed}

fan air power (3.43) divided by the *drive control electrical input power* (3.49) for the fan with variable speed drive

$$\eta_{ed} = \frac{P_u}{P_{ed}}$$

3.55

motor efficiency

η_{mot}

motor output power (3.47) divided by the *motor input power* (3.48)

$$\eta_{mot} = \frac{P_o}{P_e}$$

Note 1 to entry: See [Annex F](#).

3.56

variable speed drive efficiency

η_c

motor input power (3.48) divided by the *drive control electrical input power* (3.49)

$$\eta_c = \frac{P_e}{P_{ed}}$$

3.57

kinetic energy factor at section x

α_{Ax}

dimensionless coefficient equal to the time-averaged flux of kinetic energy through the considered cross section, A_x , divided by the kinetic energy corresponding to the mean air velocity through this cross section

$$\alpha_{Ax} = \frac{\iint_{A_x} (\rho \cdot v_{nx} \cdot v^2) dA}{q_m \cdot v_x^2}$$

where v_n is the local velocity normal to the cross-section

Note 1 to entry: Throughout this document, it shall be assumed, by convention, $\alpha_{Ax} = 1$, accepting some physical distortion of the results, for the sake of simplicity.

3.58**Reynolds number based on the exit diameter****Red**

ratio of inertial to viscous forces

$$Re_d = 0,95 \cdot \varepsilon \cdot d \cdot \frac{\sqrt{2 \cdot \rho_{up} \cdot \Delta p}}{\mu_{up}}$$

4 Symbols, abbreviated terms and subscripts**4.1 Symbols and abbreviated terms**

Symbol	Represented quantity	Definition reference	SI Unit
iCS	Common segment at the inlet side of the fan under test	8.1	—
iDS	Duct simulation at the inlet side of the fan under test	8.2	—
iLD	Long duct at the inlet side of the fan under test	8.5	—
iTC	Test chamber at the inlet side of the fan under test	9.3	—
iTS	Free test space at the inlet side of the fan under test	6.9	—
oCS	Common segment at the outlet side of the fan under test	8.3	—
oDS	Duct simulation at the outlet side of the fan under test	8.4	—
oLD	Long duct at the outlet side of the fan under test	8.5	—
oTC	Test chamber at the outlet side of the fan under test	9.4	—
oTS	Free test space at the outlet side of the fan under test	6.9	—
F, Fan	Fan under test	11	—
VSS	Variable supply system	10.1	—
iNZ	Inlet nozzle	A.5	—
dNZ	In duct nozzle	ISO 5167-1	—
mNZ	Multi nozzle	A.4	—
cOR	Orifice in chamber	A.6.4.5	—
dOR	In duct orifice	ISO 5167-1	—
iOR	Inlet orifice	A.6.4.4	—
oOR	Outlet orifice	A.6.4.3	—
<i>b</i>	Width of the rectangular section of a duct	—	M
<i>c</i>	Velocity of sound at a point	3.38	m/s
<i>c_p</i>	Specific heat capacity at constant pressure	3.13	J/kg/K
<i>C_V</i>	Specific heat capacity at constant volume	3.14	J/kg/K
<i>C</i>	Discharge coefficient	Annex A	—
<i>d</i>	Diameter, e.g. diameter of orifice or nozzle throat	Annex A	m
<i>D</i>	Diameter	—	m
<i>D_h</i>	Hydraulic diameter	3.8	m
<i>f_M</i>	Mach factor for correction of dynamic pressure	3.41	—
<i>f_θ</i>	Recovery factor for correction of temperature measurement	12.6.2	—
<i>g</i>	Acceleration due to gravity	12.8.1	m/s ²
<i>h</i>	Height of the rectangular section of a duct	12.2.2.2	M
<i>h_{rel}</i>	Relative humidity	12.9.1	—
<i>H_h</i>	Hydraulic mean depth	3.9	M

Symbol	Represented quantity	Definition reference	SI Unit
K_P	Compressibility coefficient for the calculation of fan air power P_u	15.1.8	—
L	Length of a conduit	—	m
Ma	Mach number	3.39	—
Ma_u	Peripheral Mach number	3.40	—
m	Area ratio of an orifice plate $(d/D)^2$	Annex A	—
n	Rotational frequency of the impeller	3.36	r/s
n_n	Polytropic exponent	Annex J	—
N	Impeller speed	E.2.4	r/min
p	Absolute pressure	3.27	Pa
p_e	Mean gauge pressure	3.28	Pa
p_f	Fan pressure	3.33	Pa
p_{fd}	Fan dynamic pressure	3.32	Pa
p_{fs}	Fan static pressure	3.34	Pa
P_a	Mechanical power supplied to the fan shaft	3.46	W
P_e	Motor input power	3.48	W
P_{ed}	Drive control electric input power	3.49	W
P_o	Motor output power	3.47	W
P_r	Mechanical power supplied to the impeller of the fan	3.45	W
P_u	Fan air power	3.43	W
$P_{\square}$	Perimeter	3.8 and 3.9	m
q_m	Mass flow rate	3.22	kg/s
q_{Vsg1}	Volume flow rate of the fan at stagnation conditions	3.24	m ³ /s
q_{V1}	Volume flow rate of the fan	3.23	m ³ /s
r_d	Pressure ratio for a flow meter $r_d = p_{do}/p_{up}$	Annex A	—
$r_{\Delta p}$	Pressure ratio for a flow meter $r_{\Delta p} = \Delta p/p_{do}$	Annex A	—
R	Specific gas constant	3.16	J/kg/K
Re_d	Reynolds number with the internal diameter of an in-line flow meter	3.58	—
Re_D	Reynolds number	8.6	—
Re_u	peripheral Reynolds number	14.2.3	—
t	Time	Annex C	s
t_m	Motor output torque	E.4	Nm
T	Temperature	—	°C
v	Average velocity of air	3.25	m/s
u	Tip speed of the impeller	3.37	m/s
y_f	Fan work per unit mass	3.42	J/kg
y_{fs}	Fan static work per unit mass	15.1.9	J/kg
z	Altitude	—	m
Z_k and Z_p	Auxiliary quantities	15.1.8	—
α	Flow rate coefficient of an in-line flow meter	Annex A	—
α_{Ax}	Kinetic energy factor in the section x of area A_x	3.57	—
β	Ratio of the internal diameter of an orifice or nozzle to the upstream diameter of the duct d/D	Annex A	—
β'	Ratio of the internal diameter of an orifice or nozzle to the downstream diameter of the duct	Annex A	—

Symbol	Represented quantity	Definition reference	SI Unit
Δp	Differential pressure	Annex A	Pa
ε	Expansibility factor	Annex A	—
ξ	Loss coefficient	—	—
$(\xi_n - x)_x$	Loss coefficient between planes n and x calculated for section x	—	—
η	Efficiency	15.2	—
θ	Absolute temperature	3.10	K
θ_{ind}	Measured temperature indicated by the probe ($\theta < \theta_{\text{ind}} < \theta_{\text{sg}}$)	12.6.2	K
κ	Isentropic exponent	3.15	—
Λ	Coefficient of friction loss for a straight duct	—	—
μ	Dynamic viscosity	12.9.2	Pa·s
ρ	Density of air	3.18	kg/m ³

4.2 Subscripts

1	Test fan inlet
2	Test fan outlet
3	Pressure measurement section in an inlet-side airway
4	Pressure measurement section in an outlet-side airway
5	Throat or downstream tapping for Δp for an inlet-side flow rate measurement
6	Upstream tapping for Δp and tapping for p_{up} for an outlet-side flow rate measurement
7	Upstream tapping for Δp and tapping for p_{up} for an inlet-side flow rate measurement
8	Throat or downstream tapping for Δp for an outlet-side flow rate measurement
a	Ambient atmosphere in the test space/regarding efficiency related to shaft
aux	auxiliary
b	barometer
C	converted
d	dynamic
do	downstream of a flow rate measurement device
dry	dry bulb
eq	equivalent
f	fan
h	hydraulic
L	large
m	arithmetic mean value between inlet and outlet cross-sections of the fan under test

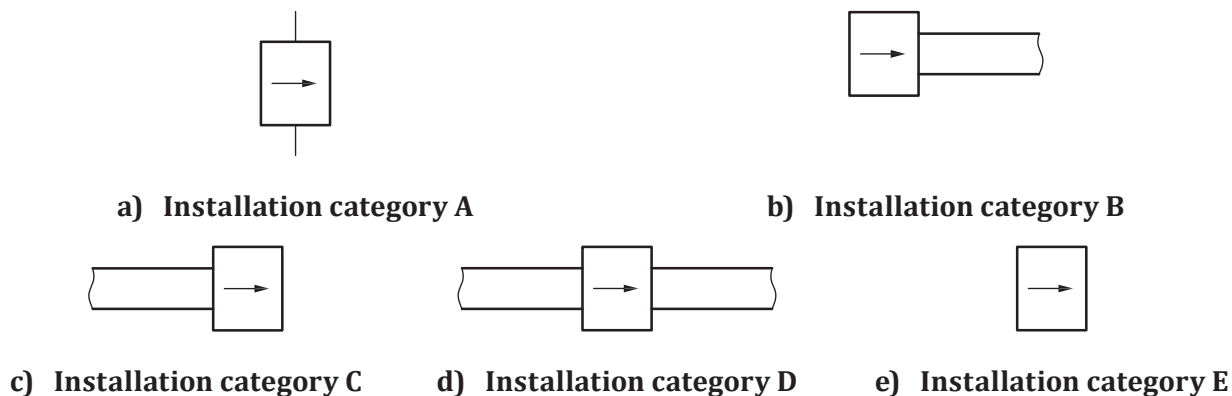
mot	motor
max	maximum
min	minimum
n	reference plane of the fan; $n = 1$ for inlet, $n = 2$ for outlet (see 15.1.2)
r	rotor/impeller
ref	reference
s	static conditions
S	small
sat	saturation conditions
sg	stagnation conditions
T	transition
Te	tested
tot	total
up	upstream of a flow rate measurement device
v	vapour
wet	wet bulb
x	section and the mean value, over time, averaged over the area of the airway cross-section

5 General

The upper limit of fan air work per unit mass is 25 000 J/kg corresponding to an increase in fan pressure approximately equal to 30 000 Pa for a mean density in the fan of 1,2 kg/m³.

The working fluid for test with standardized airways shall be atmospheric air, and the pressure and temperature shall be within the normal atmospheric range.

In ISO 13349, five fan installation categories are defined; see [Figure 1](#).



Key

- A free inlet, free outlet
- B free inlet, ducted outlet
- C ducted inlet, free outlet
- D ducted inlet, ducted outlet
- E free inlet and free outlet without a partition

Figure 1 — Installation categories

In the above classification, the terms have the following meanings.

Free inlet or outlet signifies that the air enters or leaves the fan directly from or into the unobstructed free atmosphere. Ducted inlet or outlet signifies that the air enters or leaves the fan through a duct directly connected to the fan inlet or outlet, respectively.

In this document, a number of test configurations are defined (see [Clause 6](#)) corresponding to the installation categories A, B, C and D defined in ISO 13349. The installation category E is tested according to ISO 13350 (jet fans) or other relevant standards (e.g. ISO 27327-2 for air curtains).

The fan to be tested shall be classified according to one of the categories A, B, C or D specified above. The test report shall state the category of installation for which the fan was tested. A fan adaptable to more than one installation category and test configuration will have more than one performance.

Furthermore the performance of the fan may be modified by the upstream air flow, e.g. if the velocity profile is distorted or if there is swirl.

The downstream flow generally cannot act on the flow through the impeller, but a duct at the outlet of the fan may modify its performance, and the losses in the downstream duct may be modified by the air flow at the fan outlet.

Methods of measurement and calculation for the flow rates, fan pressures and fan efficiencies are established in this document, taking into account all compressibility effects of the air. For fan pressure less than 2 000 Pa, the change of density between fan inlet and fan outlet can be neglected. Other compressibility effects can be neglected for reference velocity values not higher than 65 m/s (see [Clause 13](#)).

6 Test configurations

6.1 General

The laboratory shall test the fan as delivered; it is the responsibility of the organization supplying the fan to the laboratory to include all ancillaries are included for their intended use. The test report shall include all information to the measurement setup, i.e. the shape and position of the used ancillaries.

6.2 Category A configuration

In order to qualify for installation category A, the fan shall be tested without any inlet or outlet duct, but may be tested with the ancillaries supplied with the fan, i.e. protection grid, inlet bell, etc.

An inlet or outlet chamber is used in this case as defined in [9.4](#) and [9.5](#).

6.3 Category B configuration

An outlet duct, simulating ducted conditions, shall be used and the fan may be tested with the ancillaries supplied with the fan.

When the outlet pressure of the fan is measured in the outlet duct, a common segment at the fan outlet shall be used (see [8.4](#)). See [Annex G](#) for recommendations for using this configuration for fans with significant swirl.

6.4 Category C configuration

An inlet duct, simulating ducted conditions, shall be used and the fan may be tested with the ancillaries supplied with the fan.

When the inlet pressure of the fan is measured in the inlet duct, a common segment at the fan inlet shall be used (see [8.2](#)).

6.5 Category D configuration

An inlet duct and an outlet duct, simulating ducted conditions, shall be used and the fan may be tested with the ancillaries supplied with the fan.

When the outlet pressure of the fan is measured in the outlet duct, a common segment at the fan outlet shall be used (see [8.4](#)). See [Annex G](#) for recommendations for using this configuration for fans with significant swirl.

When the inlet pressure of the fan is measured in the inlet duct, a common segment at the fan inlet shall be used (see [8.2](#)).

6.6 Inlets and outlets

Fan inlet and outlet areas are defined in ISO 13349.

6.7 Fans with significant swirl

The performance of a fan for a defined installation category will be determined correctly with the standardized test setups of this document within a given uncertainty (see [Clause 17](#)). Fans with significant swirl (as for example, axial fans without outlet guide vanes) in installation categories B and D may have additional uncertainty. This additional uncertainty depends on fan design, operation point and test setup (see [Annex G](#)). The test report shall clearly state the geometry of duct used at the outlet of the fan.

6.8 Airways

All test airways shall be straight. Joints between airway sections shall be in good alignment and free from internal protrusions. Where provision is made for the insertion and manipulation of measuring instruments, special care shall be taken to minimize leakage and obstruction of the airway.

6.9 Test space

The assembly of the fan with its test airways shall be so situated that, when the fan is not operating, there is no draught in the vicinity of the inlet or outlet of the assembly of speed greater than 1 m/s.

Care shall be taken to avoid the presence of any obstruction which might significantly modify the air flow at inlet or outlet of the fan under test or the test configuration. For details, see [9.4.1](#) and [9.5.1](#).

Other unobstructed space at the inlet and outlet of flow-measurement devices is specified with these devices. Related dimensions of the test chambers are specified in [9.4.1](#) and [9.5.1](#).

6.10 Leakage

Leakage of the test installation between the flow rate measurement plane and the fan under test shall be negligible compared to the maximum flow rate of the fan under test.

A leakage test shall be performed prior to initial use and periodically thereafter, with corrective action taken if necessary. See [Annex C](#) for recommended leakage test methods.

6.11 Test report

All references to fan performance stated to be in accordance with this document shall also state the test configuration to which they refer. In reporting a test, the test configuration defined in [Clause 11](#) shall be stated.

7 Carrying out the test

7.1 Working fluid

The working fluid for tests with standardized airways shall be atmospheric air.

7.2 Rotational speed

For constant speed characteristics, the fan shall preferably be operated at a speed close to that specified. Where the speed is substantially different, or where the fan is intended for use with a gas other than air, or at a different density, the provisions of [Clause 14](#) and [15.3](#) shall be applied.

In the case of inherent speed characteristics, as defined in [16.4](#), the fan motor shall be operated at nominal or rated supply conditions of the motor or prime mover.

7.3 Steady operation

Before taking measurements for any point on the fan flow rating curve, the fan shall be run until steady operation is achieved. Where steady-state is not possible, a measurement may be taken and a note about the unsteadiness shall be made in the test record.

7.4 Ambient conditions

Readings of atmospheric pressure, dry bulb temperature and wet bulb temperature shall be taken within the test space during the series of observations required to determine the fan characteristic curves. If the ambient conditions are varying, sufficient readings shall be taken to obtain (for each test point on the characteristic curve by averaging) a value which is compatible with the accuracy of measurement given in this document.

7.5 Pressure readings

Pressure in the test airways shall be observed over a period of not less than 1 min for each point on the fan characteristic curve. Rapid fluctuations shall be damped at the manometer and if the readings still show random variations, a sufficient number of observations shall be recorded to ensure that a time-average is obtained within the accuracy limits given in this document.

7.6 Test for a specified duty

Tests for a specified duty shall comprise not less than three test points determining a short portion of the fan characteristic curve including the specified duty. Measured points shall be indicated in the plot.

7.7 Test for a fan characteristic curve

Tests for determining fan characteristic curves shall comprise a sufficient number of plotted test points to permit the characteristic curve to be plotted over the normal operating range. Closely spaced points will be necessary where there is evidence of sharp changes in the shape of the characteristic curve.

7.8 Operating range

Test points outside the normal operating range may be recorded and the complete fan characteristic curve plotted, for information only. Tests made outside the normal operating range will not necessarily have the accuracy expected for tests made within the normal range.

8 Airways for duct simulations

8.1 General

Standardized airways for category B, C or D ducted fan installations shall incorporate duct simulations adjacent to the fan inlet and/or outlet which are described in this clause.

8.2 Common segments at fan inlet (iCS)

This comprises the section of the inlet side test airway adjacent to the fan and incorporates a set of wall tappings in accordance with [12.8](#) as shown in [Figure 2](#).

A transition section may be used to accommodate a difference of area and/or shape within the limits indicated (see [Figure 2](#)):

$$0,95 < A_3/A_1 < 2,25 \quad \text{for circular } A_1$$

$$0,95 < A_3/A_1 \quad \text{For rectangular } A_1, \text{ there is no upper limit on } A_3 \text{ or on the aspect ratio } b/h \text{ (where } b > h), \text{ but the included angle of expansion between the short sides shall not exceed } 15^\circ \text{ and the included angle of contraction between the long sides shall not exceed } 30^\circ.$$

$$L_{T1}/D_{h3} = 1 \quad \text{For rectangular } A_1: L_{T1}/D_{h3} \geq 1 \text{ is possible (see above note to } A_3/A_1).$$

If acoustic in duct measurements are carried out at the same time as air flow performance tests, the transition shall also comply with the requirements of ISO 5136 (cited in [10.4](#)). For other test configurations, the relevant parts of ISO 13347 (all parts) shall be used.

The section adjacent to the fan inlet has the same cross-section as the fan inlet to which it is attached and its length, L_{S1} , is as given in [Formula \(1\)](#):

$$L_{S1} = D_{h1} \quad (1)$$

where

D_{h1} is the hydraulic diameter at the inlet of the fan.

If the air enters the common segment directly from the unobstructed free atmosphere or if the common segment is installed downstream of an inlet test chamber as a duct simulation, it shall be used with a bell mouth entry at its inlet end (see [Figure 3](#)).

If a throttling device or an auxiliary fan is installed upstream of the common segment, a straightener (see [10.3](#)) shall be used upstream of the common segment to provide the measuring plane 3 with swirl free conditions for reliable pressure measurement.

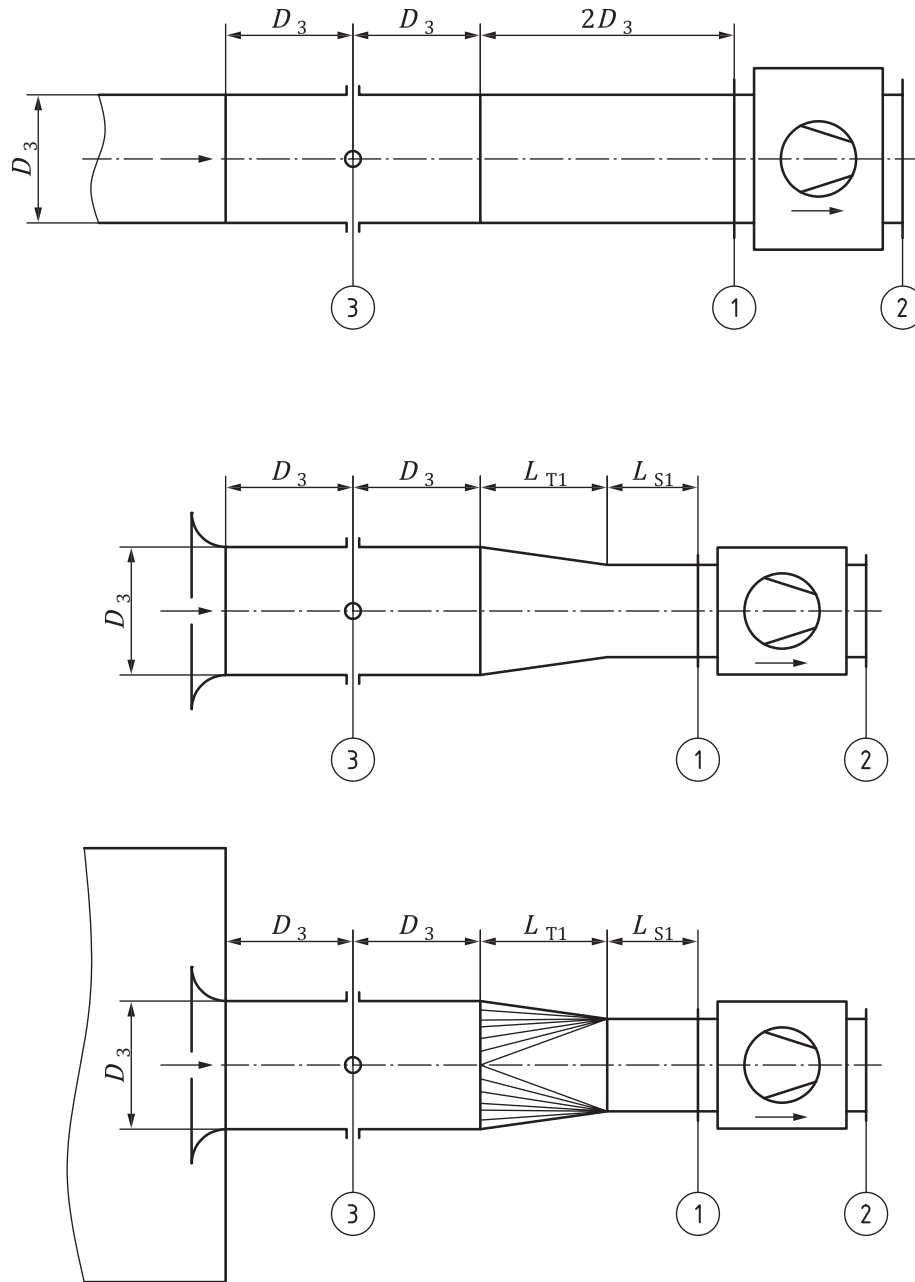


Figure 2 — Common segment at fan inlet

8.3 Inlet duct simulation (iDS)

A fan tested for use with free inlet but adaptable for ducted inlet may be converted for test from the former to the latter by attaching an inlet-duct simulation section to its inlet.

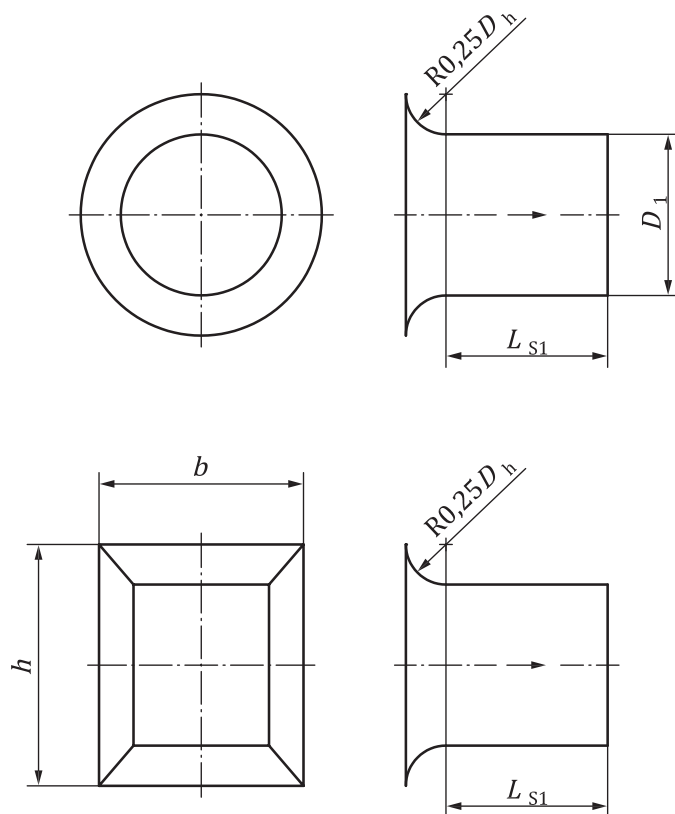


Figure 3 — Inlet duct simulation with bellmouth entry

The simulation section shall have the same cross-section as the fan inlet to which it is attached, with the length L_{S1} , given by [Formula \(2\)](#):

$$L_{S1} \geq D_{h1} \quad (2)$$

A bellmouth entry shall be fitted; geometry shown in [Figure 3](#).

An inlet length equal to L_{S1} is the normal relationship and provides a true ducted-inlet fan characteristic for any fan over the range of normal working duty. In certain cases, however, a longer duct is needed to enable the fan to develop its full ducted-inlet pressure at or near zero-volume flow. If in such cases a complete fan characteristic curve is required, it is permissible to extend this element as required, or to use the common segment of [10.3.3](#) with a bellmouth entry at its inlet end.

8.4 Common segment at fan outlet (oCS)

This comprises the section of an outlet side test airway adjacent to the fan. It incorporates a standardized flow straightener of star type in accordance with [10.3.3](#) in the central cylindrical section, together with a set of wall tappings in accordance with [12.8](#).

A transition section may be used to accommodate a difference of area and/or shape within the limits indicated (see [Figure 4](#)):

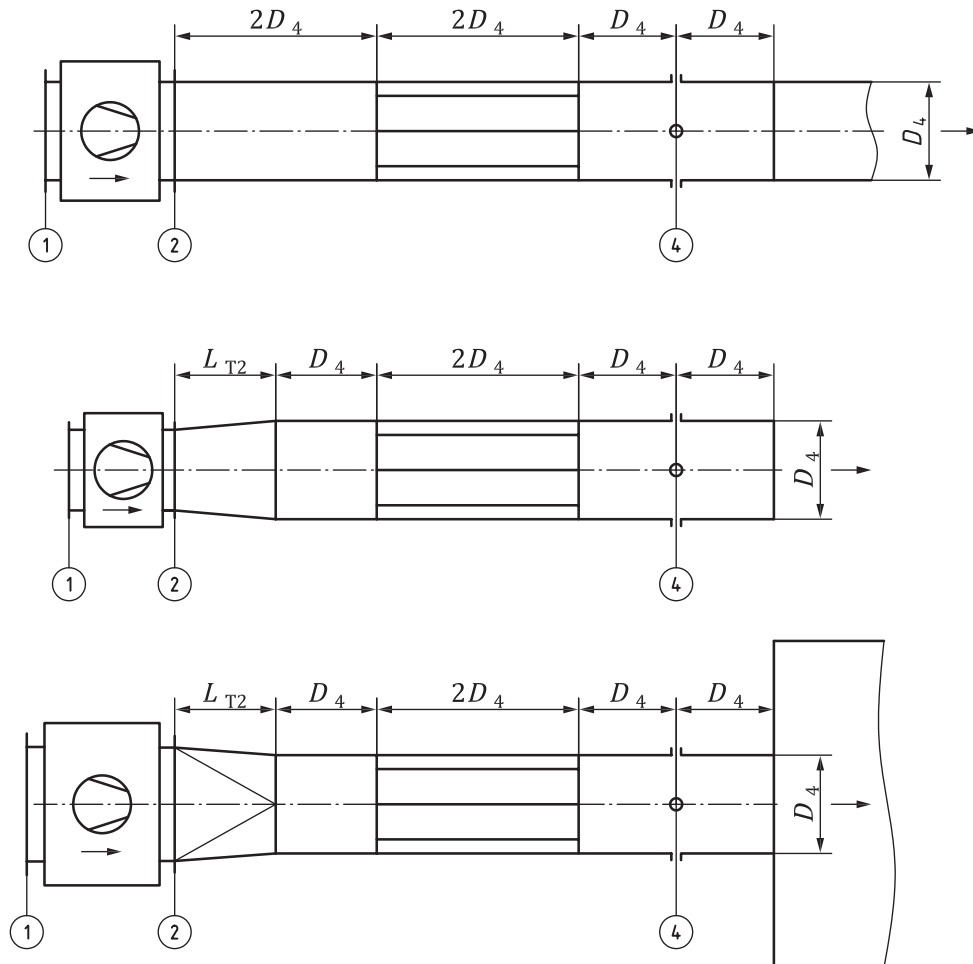
$$0,95 < A_4/A_2 < 1,07 \quad \text{for all } A_2\text{-shapes}$$

$$L_{T2}/D_4 = 1 \quad \text{for all } A_2\text{-shapes except for rectangular } A_2 \text{ with}$$

$$b_2/h_2 > 4/3 : L_{T2}D_4 = 3/4 \cdot b_2/h_2$$

If acoustic in duct measurements are carried out at the same time as air flow performance tests, the transition shall also comply with the requirements of ISO 5136 (cited in 10.4). For other test configurations, the relevant parts of ISO 13347 (all parts) shall be used.

The friction-loss coefficient of the transition section is that of a duct of diameter D_4 and length L_{T2} .



NOTE Alternatively, the pressure tapping (4) can be placed in the chamber as shown in Figure 10.

Figure 4 — Common segment at fan outlet [with flow straightener (star type shown)]

For centrifugal, cross-flow or vane-axial fans (not having significant swirl), a simplified outlet duct (8.5) may alternatively be fitted to obtain a type B or D configuration when discharging to atmosphere (oTS) or an outlet test chamber (oTC).

For large fans (outlet diameter 800 mm or larger), it may be difficult to carry out the tests with standardized common airways at the outlet including a straightener. In this case, by mutual agreement between the parties concerned, the fan performance may be measured using a duct simulation on the outlet side (8.5). Results obtained in this way may differ to some extent from those obtained using the common segment at fan outlet (8.4), especially if the fan produces a large swirl.

8.5 Outlet duct simulation (oDS)

A fan tested for use with free outlet but adaptable to ducted outlet may be converted for test from the former to the latter by attaching an outlet-duct simulation section to its outlet (see Figure 5).

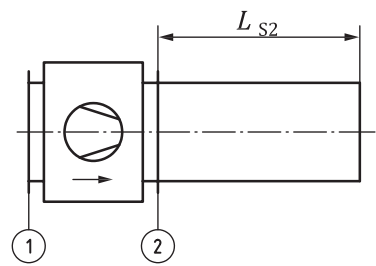


Figure 5 — Duct simulation at fan outlet

The outlet duct simulation shall be of the same cross-section as the fan outlet and the length shall be determined by the condition given in [Formula \(3\)](#):

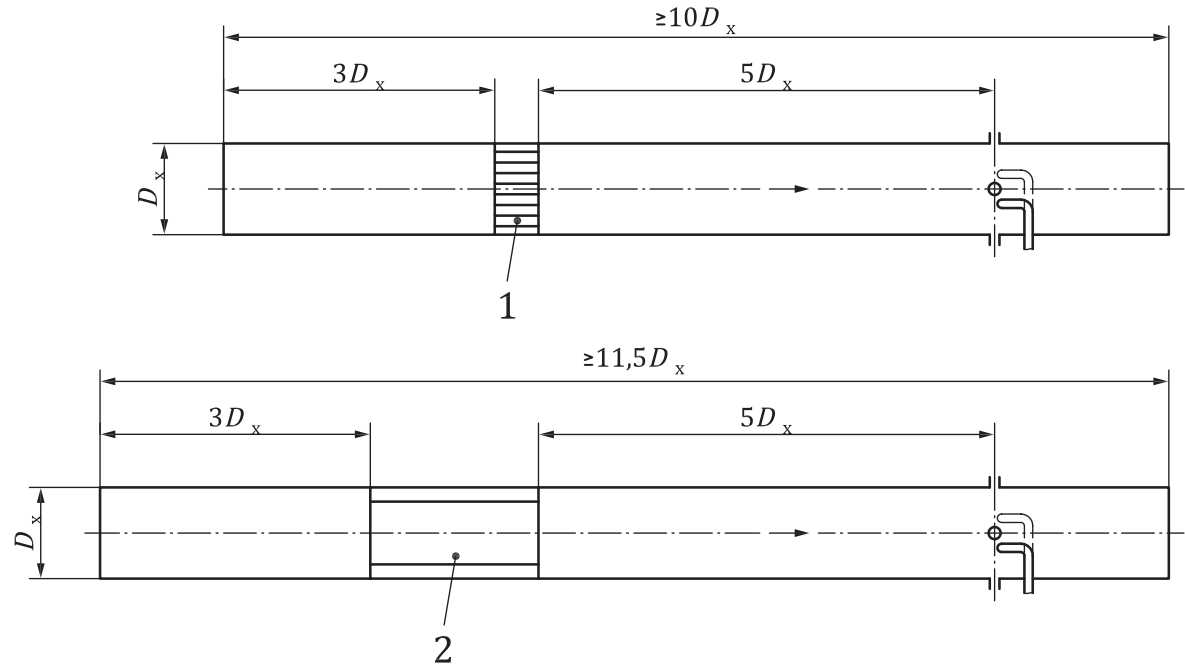
$$2 \leq L_{S2} / D_{h2} \leq 4 \tag{3}$$

The outlet duct simulation can be used with an outlet test chamber (oTC) in accordance with [8.4](#) or outlet test space (oTS).

The outlet static pressure of the fan under test is not measured in this duct but considered as equal to the static pressure in the outlet test space (oTS) or the outlet test chamber (oTC).

8.6 Long duct (LD)

A long duct shall be straight and have a uniform circular cross-section. Duct length between the straightener and the Pitot static tube shall be not less than $5D_x$.



- Key
- 1 cell straightener
 - 2 star straightener

Figure 6 — Long duct

8.7 Loss allowances for standardized airways

Conventional allowances given in this subclause shall be made for airway friction in tests with standardized airways.

Friction factors for duct losses may be based on either hydraulic diameter or hydraulic mean depth. Care should be taken to ensure the correct value of friction factor is used. [Figure 7](#) shows values for smooth ducts.

The coefficient of friction loss can be determined from [Formula \(4\)](#):

$$\Lambda = 0,005 + 0,42(Re_{D3})^{-0,3} \quad (4)$$

where Λ is the coefficient of friction loss for a length of one diameter of a straight duct.

These allowances depend on the Reynolds number, Re_D , of the flow in the test airway and are based on fully developed flow in smooth ducts, irrespective of the actual flow pattern produced by the fan.

The allowances are calculated for the inlet common segments described in [8.7.1](#), the outlet common segments described in [8.4](#) and the long duct described in [8.6](#) between the fan and the plane of pressure measurement. The same allowances shall be made when transition sections are incorporated.

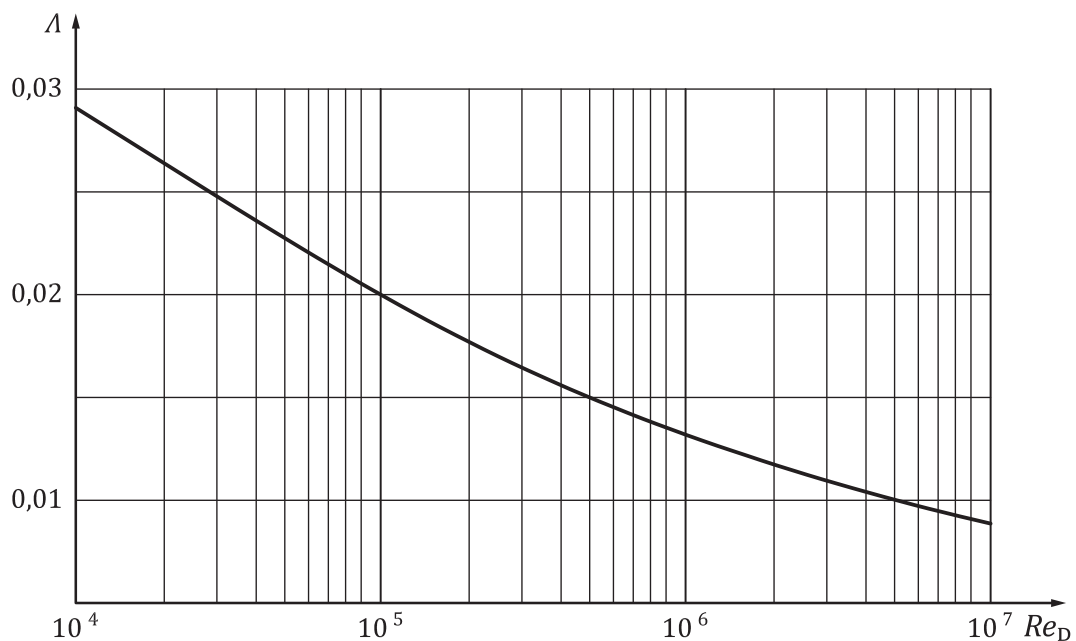


Figure 7 — Coefficient of loss for a length of one diameter of a straight duct

8.7.1 Loss allowances for an inlet common segment (iCS)

The conventional loss coefficient $(\xi_{3-1})_3$ between plane 3 and the inlet is given by [Formula \(5\)](#):

$$(\xi_{3-1})_3 = 0,015 + 1,26(Re_{D3})^{-0,3} \quad (5)$$

where

$$Re_{D3} = \frac{v_{m3} D_3 \rho_3}{\mu_3} \approx \frac{v_{m3} D_3}{15} \times 10^6$$

in standard air.

The energy losses between planes 3 and 1 are given by [Formula \(6\)](#):

$$\Delta p_{3-1} = (\xi_{3-1})_3 \frac{\rho 3 v_{m3}^2}{2} f_{M3} \quad (6)$$

8.7.2 Loss allowances for inlet duct simulation (iDS)

There are no losses allowed for this inlet duct.

8.7.3 Loss allowances for outlet common segments (oCS)

8.7.3.1 With a star straightener (oCS)_{star}

The conventional loss coefficient of the star straightener including the external duct is given by [Formula \(7\)](#):

$$\xi_{\text{star}} = 0,95 \cdot (Re_{D4})^{-0,12} \quad (7)$$

with

$$Re_{D4} = \frac{4 \cdot q_m}{\pi \cdot D_4 \cdot \mu_4}$$

The conventional loss coefficient $(\xi_{2-4})_4$ between the fan outlet 2 and the measuring plane 4 is given by [Formula \(8\)](#):

$$(\xi_{2-4})_{4\text{-star}} = \Lambda \cdot \frac{L_{2-4}}{D_{h4}} + \xi_{\text{star}} \quad (8)$$

where

L_{2-4} is the length of the duct between the fan outlet 2 and the measurement section 4;

Λ is the coefficient of friction loss for a length of one diameter of a straight duct given by

$\Lambda = 0,005 + 0,42 \cdot (Re_{D4})^{-0,3}$ and is plotted against the Reynolds number in [Figure 7](#).

8.7.3.2 With a cell straightener (oCS)_{cell}

The coefficient of friction loss, Λ , for a length of one diameter of a straight duct is given in [8.7.3.1](#).

The ratio of equivalent length L_{eq} of a cell-straightener to hydraulic diameter D_h of the duct is given by [Formula \(9\)](#):

$$\frac{L_{eq}}{D_h} = \frac{15,04}{\left[1 - 26,65 \cdot \frac{e}{D_h} + 184,6 \cdot \left(\frac{e}{D_h} \right)^2 \right]^{1,83}} \quad (9)$$

where

e is the vane thickness.

The conventional loss coefficient $(\xi_{2-4})_{4,\text{cell}}$ is given by [Formula \(10\)](#):

$$(\xi_{2-4})_{4,\text{cell}} = \Lambda \cdot \left[\frac{L_{2-4}}{D_{h4}} + \frac{L_{\text{eq}}}{D_{h4}} \right] \quad (10)$$

where

L_{2-4} is the length of the duct between the fan outlet 2 and the measurement section 4.

8.7.4 Loss allowances for duct simulation at outlet (oDS)

There are no losses allowed for this outlet duct.

8.7.5 Loss allowances for long duct (LD)

8.7.5.1 With a star straightener (LD)_{star}

The calculations in [8.7.3.1](#) shall apply.

8.7.5.2 With a cell straightener (LD)_{cell}

The calculations in [8.7.3.2](#) shall apply.

9 Standardized test chambers

9.1 General

A chamber may be incorporated in a laboratory setup to provide a measuring station or to simulate the conditions the fan is expected to encounter in service, or both.

The test chamber cross-section may be circular or rectangular.

9.2 Pressure tapings

The wall tapings in the measuring planes shall be in accordance with the requirements of [12.8](#) and be equally spaced around a cylindrical chamber or on each side of a rectangular chamber.

9.3 Flow-settling means

9.3.1 General

Flow-settling means shall be installed in chambers to provide the required flow patterns when necessary.

The effectiveness of the airflow settling means in all chambers shall be verified by tests as described in [9.3.2](#), [9.3.3](#), and [9.3.4](#).

Some validation tests require that the flow and the pressure be determined prior to the settling means having proved their effectiveness. It can be assumed that the tests taken in this condition (with the non-verified settling means) are sufficiently accurate to be used to establish acceptance criteria.

Once the flow settling means have demonstrated that all applicable acceptance criteria have been met, the chamber may be used for all future testing within the limits defined by the acceptance criteria.

9.3.2 Piezometer ring check

Individual pressure readings for each pressure tap of the piezometer ring are to be measured. When the mean of these readings is less than or equal to 1 000 Pa (4 inch water gauge), all of the individual readings shall be within 5 % of the mean. When the mean of these readings is greater than 1 000 Pa (4 inch water gauge) all of the individual readings shall be within 2 % of the mean (see also [12.8.10](#)).

9.3.3 Blow through verification test

This test evaluates the ability of the airflow settling means to provide a substantially uniform airflow ahead of a measurement plane. For this test, equally spaced measurement points are located in a plane $0,1D_h$ downstream of the settling means. The number of measurement points shall be in accordance with ISO 5802.

For tests of settling means upstream of the nozzle wall, the auxiliary fan should be set at its maximum flow rate, the entire nozzle shall be open, the inlet of the chamber shall be open and the inlet area shall be equal to the largest area allowed by the chamber cross sectional area.

For tests of settling means upstream of the test fan, the auxiliary fan shall be set at its maximum flow rate, half of the nozzles shall be open, the outlet of the chamber shall be open and the outlet area shall be equal to the largest area allowed by the chamber cross sectional area.

The flow velocities shall be measured and the average determined. If the maximum velocity is less than 2 m/s (400 ft/min) or if the maximum velocity value does not exceed 125 % of the average, the settling screens are acceptable.

9.3.4 Outlet chamber reverse flow verification test

One purpose of the settling means is to absorb the kinetic energy of an upstream jet and allow its normal expansion as if in an unconfined space. This requires some backflow to supply the air to mix at the jet boundaries. If the settling means are too restrictive, excessive backflow will result.

A series of tests shall be run to verify that reverse flow is not excessive at fan static pressure measurement plane. Each test shall be run with a varying opening in the chamber entrance starting from 11 % of the chamber area and proceeding to lower percentage openings. Each test shall be run with all of the nozzles open and the auxiliary at its maximum flow rate. At each test, it shall be verified that the static pressure downstream of the settling means is less than the fan static pressure measurement plane. The series of tests may be stopped at the first set of conditions that verify the above requirement.

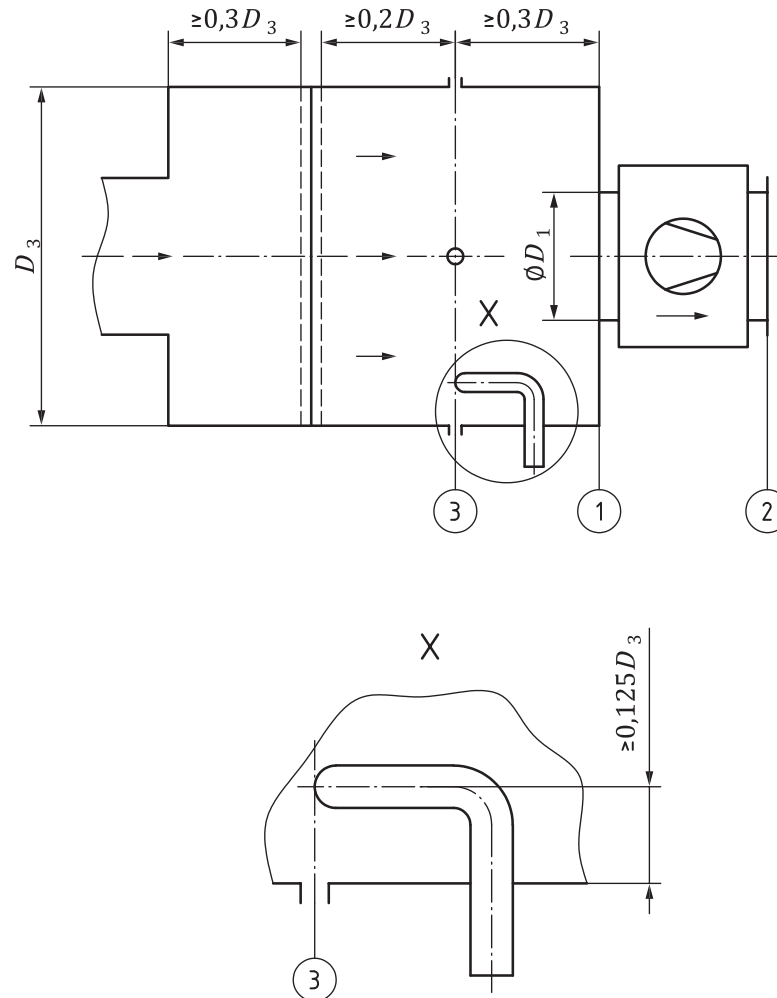
9.4 Standardized inlet test chambers (iTC)

9.4.1 Test chambers

The test chamber cross-section may be circular with inside diameter D_3 or rectangular $b_3 \cdot h_3$ with $2/3 < b_3/h_3 < 3/2$.

The dimension D_3 in the following figures corresponds to the hydraulic diameter of the cross-section given in [Formula \(11\)](#):

$$D_3 = D_{h3} \quad (11)$$



NOTE Wallappings and Pitot tube can be used alternatively or together.

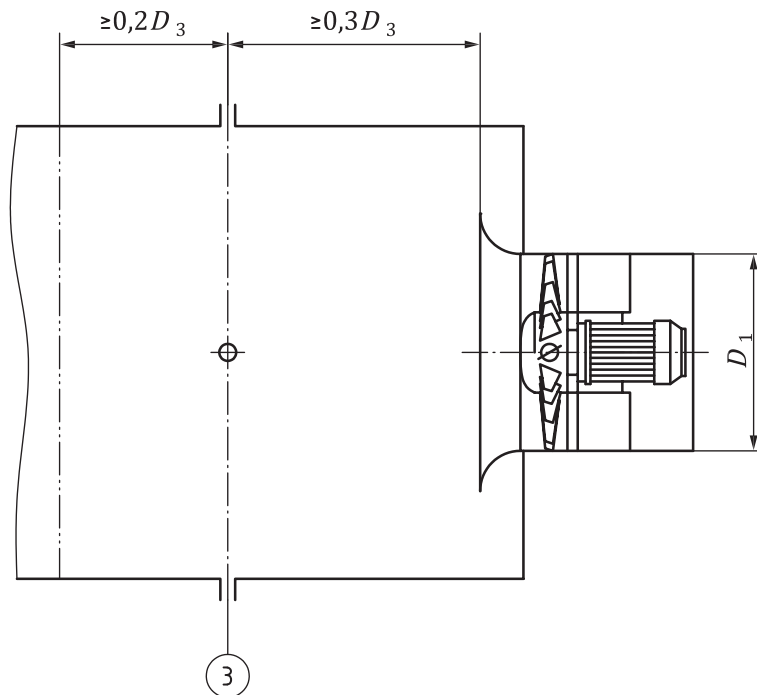
Figure 8 — Inlet side test chamber

The length of the chamber shall be sufficient to accommodate any fan to be tested without infringing on the minimum distance shown in [Figure 8](#) and [Figure 9](#).

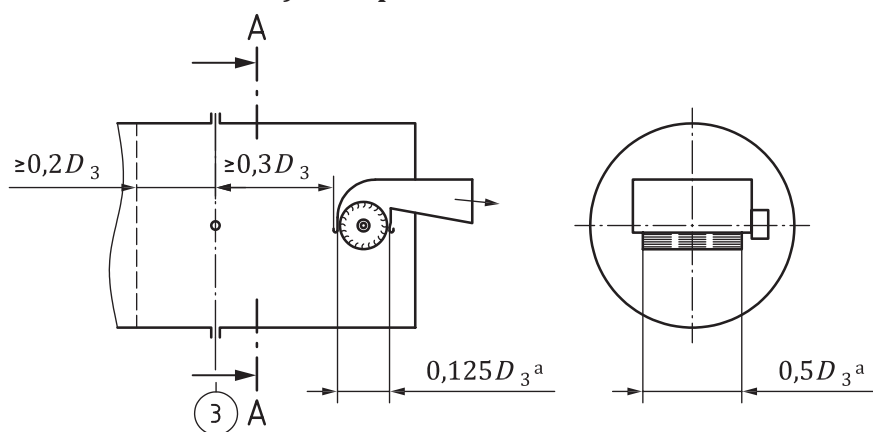
For fans with an inlet-side drive or double-inlet fans, where a corresponding minimum distance is necessary in the chamber between the pressure tapping and the next segment of the fan depending on the installation conditions, it will be necessary to use a test chamber extended in length compared with the minimum dimensions indicated in [Figure 9](#).

The pressure-measuring plane 3 is (see [Figure 8](#) and [Figure 9](#))

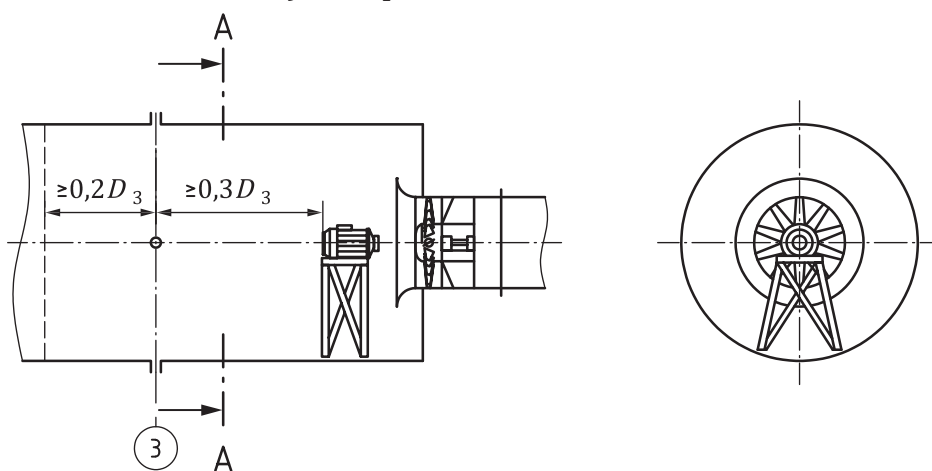
- at least $0,3 \cdot D_3$ upstream of the first downstream distortion, and
- at least $0,2 \cdot D_3$ downstream of the flow-settling means.



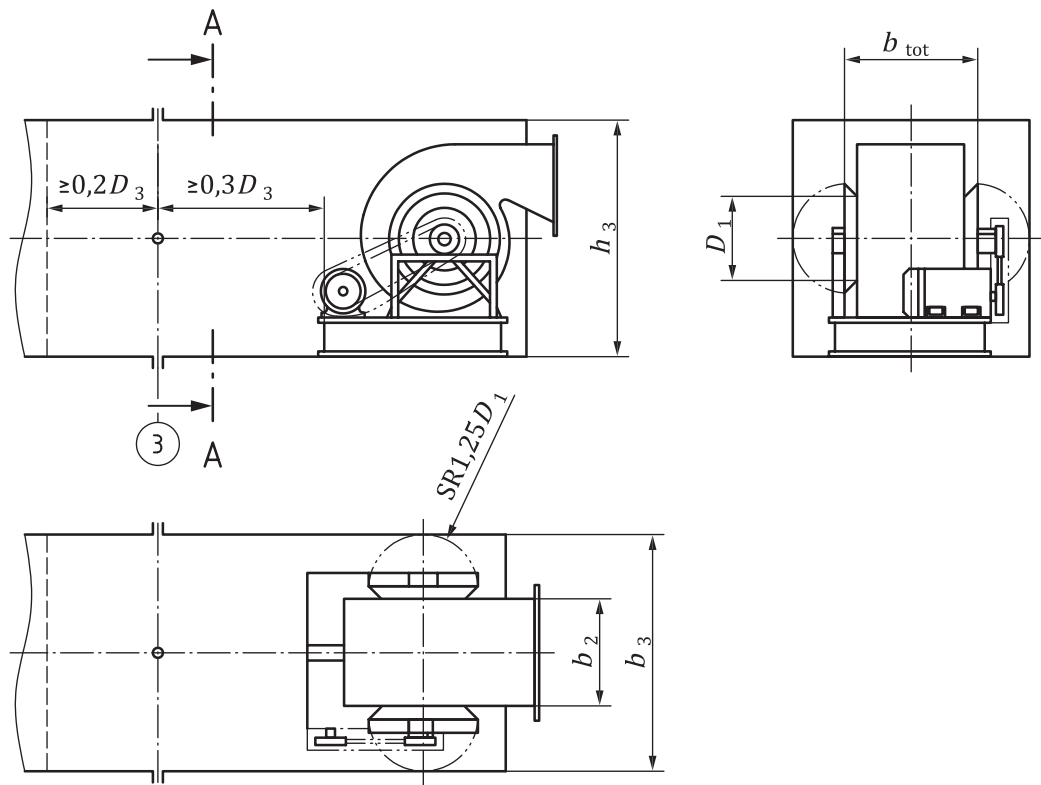
a) Example of an axial fan



b) Example of a cross-flow fan



c) Example of a fan with motor on the inlet side



d) Example of a double-inlet centrifugal fan (SR indicates spherical radius)

Key

a Inlet (maximum dimensions).

NOTE The fan illustrated has the maximum permissible dimensions.

Figure 9 — Examples for fan installations at inlet side test chambers

9.4.2 Fan under test

Inlet chambers shall have a cross-sectional area greater than five times the fan inlet area, as given in [Formula \(12\)](#):

$$A_3 \geq 5 \cdot A_1 \quad (12)$$

If there is more than one inlet, they shall be so located that the flow remains as symmetrical about the chamber axis as possible.

In a chamber of rectangular cross-section, any side shall be greater than twice the inlet diameter, as given in [Formula \(13\)](#).

$$b_3 \geq 2D_1 \quad (13)$$

When testing a double-inlet fan, the minimum width of the chamber shall be capable of accommodating both inlets. It is expedient to choose a chamber with rectangular cross-section, where the chamber width, b_3 , is the sum of the fan width, b_{tot} , and an open space surrounding the two intake openings corresponding to a hemisphere of radius equal to $1,25 \cdot D_1$ as shown in [Figure 9 d\)](#).

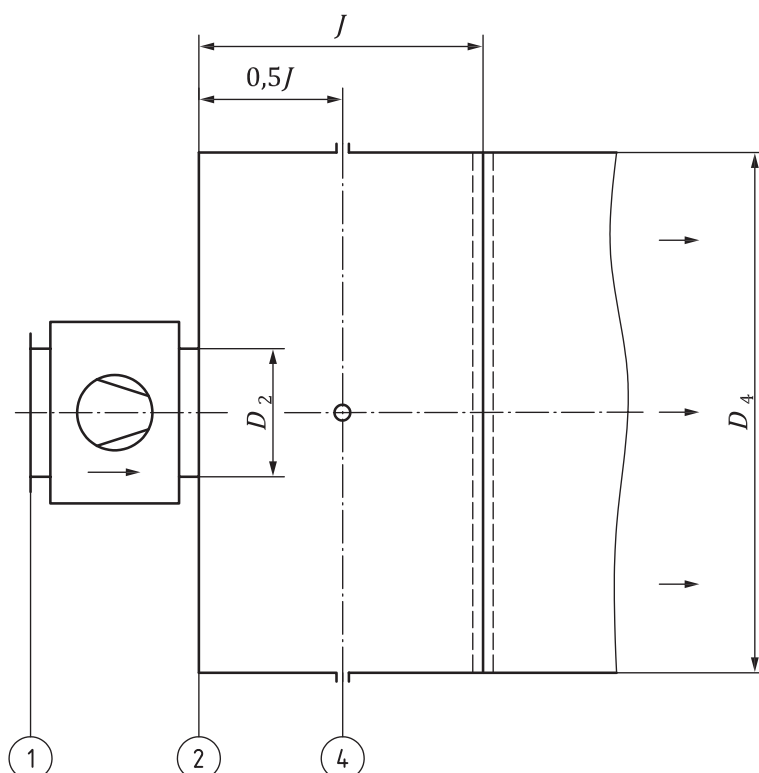
9.5 Standardized outlet test chambers (oTC)

9.5.1 Test chambers

The test chamber cross-section may be circular with inside diameter D_4 , rectangular $b_4 \cdot h_4$ with $2/3 < b_4/h_4 < 3/2$.

The dimensions D_2 and D_4 in [Figure 10](#) correspond to the hydraulic diameter of the cross-section given in [Formula \(14\)](#):

$$D_4 = D_{h4} \quad (14)$$



NOTE 1 The distance J is equal to at least the diameter of the outlet duct for fans with axis of rotation perpendicular to the discharge flow ($J \geq D_{h2}$), and to at least twice the diameter of the outlet duct for fans with axis of rotation parallel to the discharge flow ($J \geq 2 \cdot D_{h2}$).

NOTE 2 Pressure tapping (4) can be placed in the chamber as shown in [Figure 10](#) for fans with uniform flow without swirl.

Figure 10 — Outlet side test chambers

9.5.2 Fan under test

The size of the outlet chamber is very large relative to the fan size (equivalent to a large open space).

An outlet test chamber (see [Figure 10](#)) shall have a cross-sectional area at least nine times the area of the fan outlet or outlet duct for fans with axis of rotation perpendicular to the discharge flow, as given in [Formula \(15\)](#):

$$A_4 \geq 9 \cdot A_2 \quad (15)$$

The cross-sectional area of the outlet test chamber for fans with an axis of rotation parallel to the discharge flow shall be at least 16 times the area of the fan outlet or outlet duct, as given in [Formula \(16\)](#):

$$A_4 \geq 16 \cdot A_2 \quad (16)$$

10 Various component parts for a laboratory setup

10.1 General

A laboratory setup is a combination of test chambers, ducts, flow rate or pressure measuring units, straighteners, transition parts and a variable supply system.

10.2 Variable supply system

10.2.1 General

The variable supply system is installed preferably at the outlet of the test configuration or separated from the fan under test and from the flow rate or pressure measuring units by means of a test chamber or a duct of at least $2D$. It is used to vary the point of operation in the laboratory setup and may include a throttling device, an auxiliary booster fan or a combination of both.

10.2.2 Throttling device

Throttling devices may be used to control the point of operation of the fan under test. On the downstream side of the throttling device in a duct, a straightener shall be used to prevent flow disturbances at sections of flow or pressure measurements or at the inlet of the fan under test.

10.2.3 Auxiliary fan

Auxiliary fans may be used to control the point of operation of the fan under test. They shall be designed to produce sufficient pressure at the desired flow rate to overcome losses through the test setup. Flow-adjustment means, such as dampers, pitch control or speed control may be required. Auxiliary fans shall not create surge or pulse flow during test. A cell straightener shall be interposed between the auxiliary fan and any test airway to which it is connected to prevent flow disturbances at sections of flow or pressure measurements or at the inlet or the outlet of the fan under test.

10.3 Straightener

10.3.1 General

In the presence of swirl, simple measurements of pressure or volume flow are impossible. Therefore, a straightener must be included when tests are to be taken in a duct on the outlet side of the fan. Even in cases of axial fans with guide vanes, a straightener must always be used upstream of a static or dynamic pressure measuring plane located within a test duct at the fan outlet.

10.3.2 Cell straightener

The cell straightener is used to reduce swirl. It does not improve asymmetric velocity distributions.

The cell straightener consists of a nest of cells of equal cross-section (hexagonal, square, etc.) each with width w and length L . The vane thickness e shall not exceed $0,005D$ (see [Figure 11](#)).

$$w = 0,075D$$

$$L = 0,45D$$

$$e \leq 0,005D$$

All dimensions shall be within $\pm 0,005D$ except e .

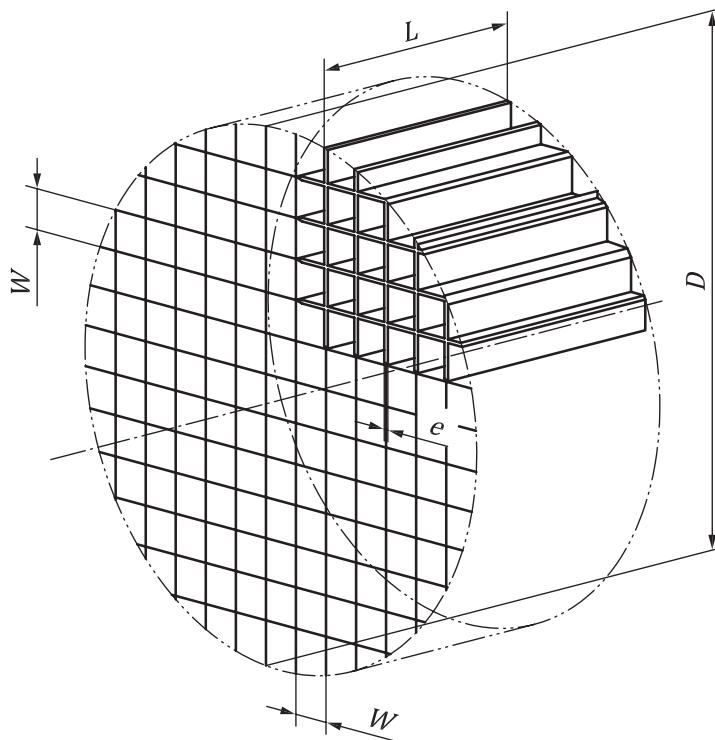


Figure 11 — Cell type flow straightener

10.3.3 Star straightener

The star straightener is designed to eliminate swirl but is of little use in equalization of asymmetric velocity distributions. It allows, unlike the cell type, the static pressure to equalize radially as the air flows through it.

The star straightener, as shown in [Figure 12](#), is constructed of eight radial blades of length $2D$ (with a $\pm 1\%$ tolerance) and of thickness not greater than $0,007D$ for pressure loss considerations. The blades will be arranged to be equidistant on the circumference with the angular deviation being no greater than 5° between adjacent plates.

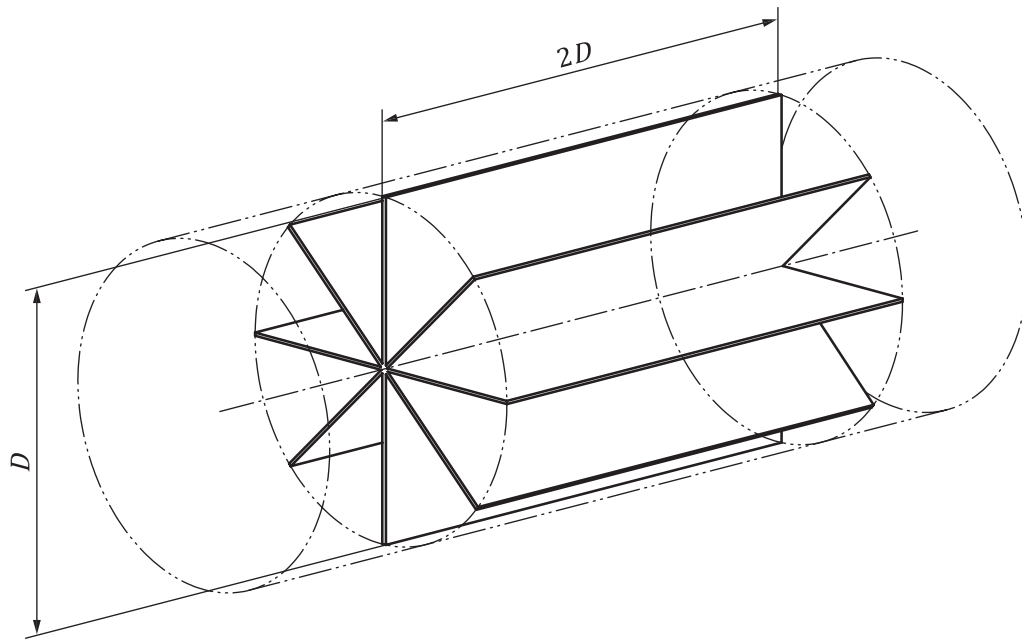


Figure 12 — Star type flow straightener

10.4 Transition parts

10.4.1 General

In [8.2](#) and [8.4](#), transition parts are defined for the connections between the fan under test and the common segments. Further transition parts will be needed to connect setup-components of different cross-sectional shape or size, which can be used in both flow directions and shall be in accordance with the condition given in [Formula \(17\)](#):

$$L \geq 4 \cdot \left[\sqrt{\frac{4 \cdot A_L}{\pi}} - \sqrt{\frac{4 \cdot A_S}{\pi}} \right] \quad (17)$$

where

A_L is the larger area of the transition part;

A_S is the smaller area of the transition part.

If acoustic in duct measurements are carried out at the same time as air flow performance tests, the transition shall also comply with the requirements of ISO 5136 (cited in [10.3](#)). For other test configurations, the relevant parts of ISO 13347 (all parts) shall be used.

10.4.2 Rectangular/circular transition

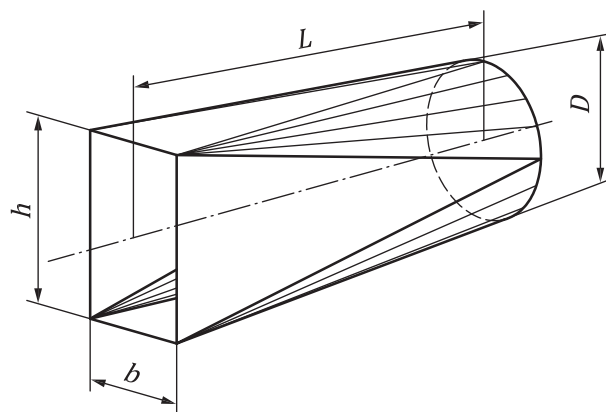


Figure 13 — Rectangular/circular transition

10.4.3 Circular/circular transition

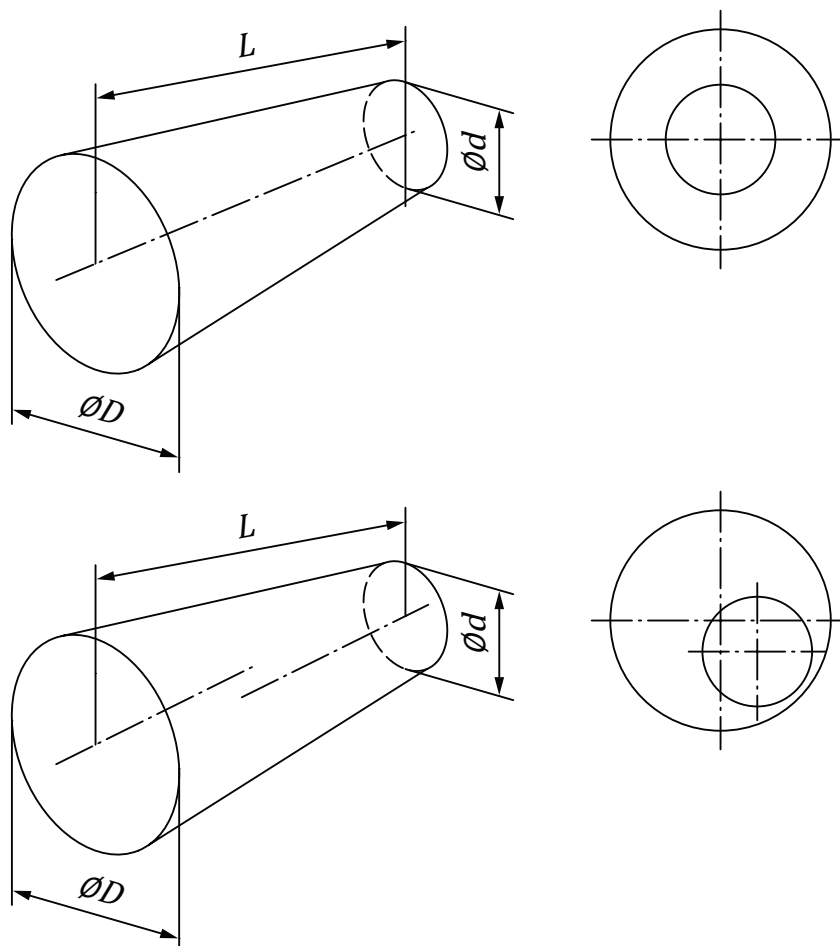
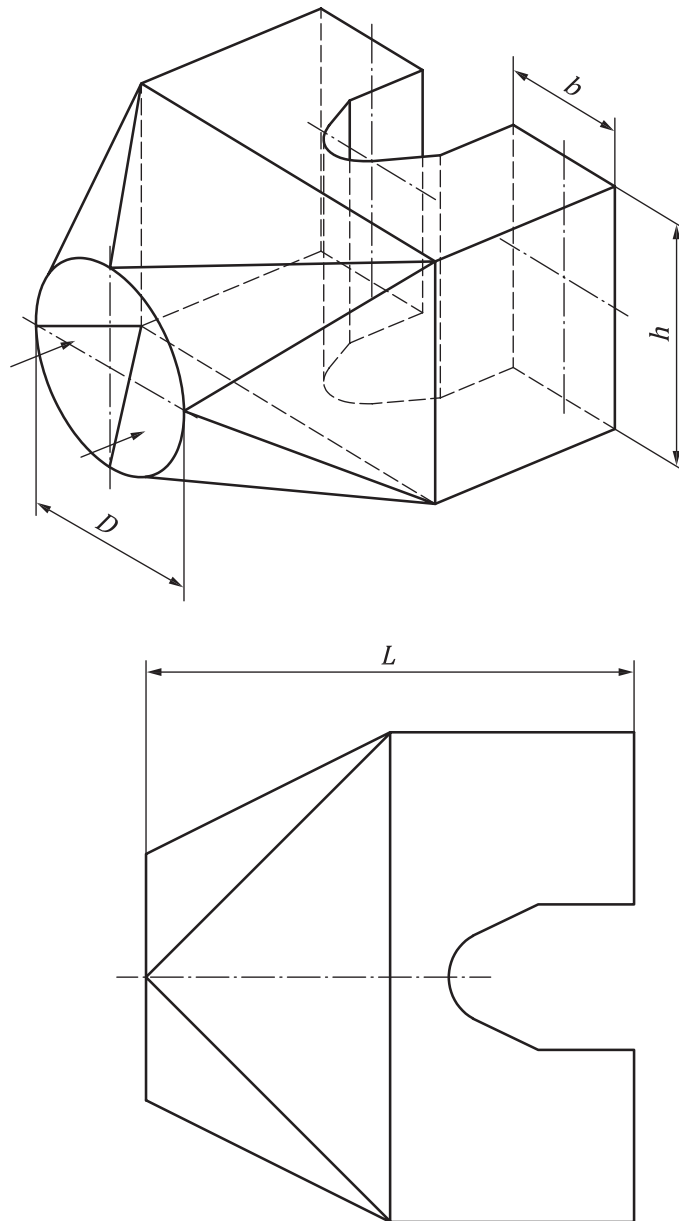


Figure 14 — Circular/circular transition

10.4.4 Connection for double-inlet fans



NOTE A_L is the total area of $2b \cdot h$, $A_L = 2b \cdot h$. Outlet cross-section of $2b \cdot h$ is be smaller or equal to circular inlet cross-section.

Figure 15 — Connection for double inlet fans

11 Standard test configurations

11.1 Units

Following defined units are to combine for setup configurations of type A, B, C and D. Restrictions of their use are indicated. Some examples are shown in [Annex K](#).

Fan under test:

Fan