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Water-source heat pumps — Testing and rating for performance —

Part 1:
Water-to-air and brine-to-air heat pumps

Pompes à chaleur à eau — Essais et détermination des caractéristiques de performance —

Partie 1: Pompes à chaleur eau-air et eau glycolée-air

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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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

This second edition cancels and replaces the first edition (ISO 13256-1:1998), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Significant updates to the formatting, symbols, and terms and definitions, have been included to more closely align with other pertinent ISO standards and the latest ISO requirements.

— The original water loop heat pump (WLHP), ground water heat pump (GWHP) and ground loop heat pump (GLHP) application rating designations, specifying entering liquid source rating test conditions, have been replaced with High, Medium, and Low source temperature range conditions to represent a wider operating map at both standard and partially loaded application rating conditions. It is now possible, when all three (High, Medium and Low) temperature ranges are specified by the manufacturer for energy modelling programs to interpolate performance at other entering water temperatures than those used in the standard.

— Specific antifreeze solution composition requirements have been removed to eliminate prescriptive language and promote industry innovation of novel and improved antifreeze solutions.

— Airflow testing requirements have been updated to align with the complexities of testing more sophisticated constant airflow electronically commutated fan motors.

— Testing tolerances and uncertainties have been harmonized with other pertinent ISO standards.

— Annexes have been added and/or significantly updated that harmonize with other pertinent ISO standards.

A list of all parts in the ISO 13256 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document covers heating and cooling systems which are generally referred to as “water-source heat pumps.” These systems generally include an indoor coil with air-moving means, a compressor, and a refrigerant-to-water or refrigerant-to-brine heat exchanger. A system may provide both heating and cooling, cooling-only, or heating-only functions.

Water-source heat pumps — Testing and rating for performance —

Part 1: Water-to-air and brine-to-air heat pumps

1 Scope

1.1 This document establishes performance testing and rating criteria for factory-made residential, commercial and industrial, electrically-driven, mechanical- compression type, water-to-air and brine-to-air heat pumps. The requirements for testing and rating contained in this document are based on the use of matched assemblies.

1.2 Equipment designed for rating at one liquid temperature range under this document may not be suitable at all liquid temperature ranges covered in this document.

1.3 This document does not apply to the testing and rating of individual assemblies for separate use, nor to the testing and rating of heat pumps covered in ISO 5151, ISO 13253 or ISO 13256-2.

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 817, *Refrigerants — Designation and safety classification*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
water-to-air heat pump
brine-to-air heat pump
heat pump which consists of one or more factory-made assemblies which normally include an indoor conditioning coil with air-moving means, compressor(s), and refrigerant-to-water or refrigerant-to-brine heat exchanger(s), including means to provide both cooling and heating, cooling-only, or heating-only functions

Note 1 to entry: When such equipment is provided in more than one assembly, the separated assemblies should be designed to be used together.

Note 2 to entry: Such equipment may also provide functions of sanitary water heating, air cleaning, dehumidifying, and humidifying.

3.2
water-loop heat pump
water-to-air heat pump using liquid circulating in a common piping loop functioning as a heat source in `heating mode and/or heat sink in cooling mode

Note 1 to entry: The temperature of the liquid loop is usually within a range of 10 °C to 30 °C.

3.3
ground-water heat pump
water-to-air heat pump using water pumped from a well, lake, or stream functioning as a heat source in heating mode and/or heat sink in cooling mode

Note 1 to entry: The temperature of the water is related to the climatic conditions and is generally constant within the range from 5 °C to 25 °C for deep wells.

3.4
ground-loop heat pump
brine-to-air heat pump using a brine solution circulating through a subsurface piping loop functioning as a heat source in heating mode and/or heat sink in cooling mode

Note 1 to entry: The heat exchange loop may be placed in horizontal trenches or vertical bores, or be submerged in a body of surface water.

Note 2 to entry: The temperature of the brine is related to the heat exchange load and climatic conditions and is generally within a range from −5 °C to 40 °C.

3.5
total cooling capacity
amount of sensible and latent heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Expressed in units of watts.

3.6
net total cooling capacity
total cooling capacity with fan power adjustment

Note 1 to entry: Expressed in units of watts.

3.7
heating capacity
amount of heat that the equipment can add to the conditioned space in a defined interval of time

Note 1 to entry: Expressed in units of watts.

3.8
net heating capacity
heating capacity with fan power adjustment

Note 1 to entry: Expressed in units of watts.

3.9
rated voltage
voltage shown on the nameplate of the equipment

Note 1 to entry: Expressed in units of volts.

3.10
rated frequency
frequency shown on the nameplate of the equipment

Note 1 to entry: Expressed in units of Hz.

3.11
energy efficiency ratio
EER
ratio of the net total cooling capacity to the effective power input at any given set of rating conditions

Note 1 to entry: Expressed in units of watt per watt.

3.12
coefficient of performance
COP
ratio of the net heating capacity to the effective power input of the equipment at any given set of rating conditions

Note 1 to entry: Expressed in units of watt per watt.

3.13
standard air
dry air at 20,0 °C and at a standard barometric pressure of 101,325 kPa, having a mass density of 1,204 kg/m^3

3.14
effective power input
average electrical power input to the equipment within a defined interval of time; i.e. the sum of:

— the power input for operation of the compressor excluding additional electrical heating devices,

— the power input of all control and safety devices of the equipment, and

— the proportional power input of the conveying devices for the transport of the heat transfer media through the heat pump only (e.g. fans, pumps, whether internal or external, whether provided with the equipment or not)

Note 1 to entry: Expressed in units of watts.

3.15
latent cooling capacity
amount of latent heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Expressed in units of watts.

3.16
sensible cooling capacity
amount of sensible heat that the equipment can remove from the conditioned space in a defined interval of time

Note 1 to entry: Expressed in units of watts.

3.17
brine
heat transfer liquid that has a freezing point lower than the freezing point of water

3.18
external static pressure difference
Δ_{pe}
pressure difference measured between the air (or water/brine) outlet section and the air (or water/brine) inlet section of the unit, which is available for overcoming the pressure drop of any additional ducted air (or water/brine) circuit

Note 1 to entry: Expressed in units of pascals.

3.19
internal static pressure difference
Δ_{pi}
pressure difference measured between the air (or water/brine) outlet section and the air (or water/brine) inlet section of the unit, which corresponds to the total pressure drop of all components on the air (or water/brine) side of the unit.

Note 1 to entry: Expressed in units of pascals.

3.20
fixed capacity heat pump
equipment which does not have possibility to change its capacity

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.21
two-stage capacity heat pump
equipment where the capacity is varied by two steps

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.22
multi-stage capacity heat pump
equipment where the capacity is varied by three or four steps

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.23
variable capacity heat pump
equipment where the capacity is varied by five or more steps to represent continuously variable capacity

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.24
standard rating conditions
operating conditions while establishing the standard rating net cooling and/or heating capacities

Note 1 to entry: These conditions correspond to an operation of the heat pump at full capacity, in relation to the source side.

3.25
application rating conditions
operating conditions while establishing additional cooling and/or heating capacities

Note 1 to entry: These conditions correspond to an operation of the heat pump at reduced capacity, in relation to the source side.

3.26
standard rating capacity
net cooling and/or heating capacity measured at standard rating conditions

4 Symbols

Symbol	Description and Units
A_n	nozzle area, m^2
α	pressure ratio
C_d	nozzle discharge coefficient
c_{pa1}	specific heat of dry air entering indoor side, J/kg·K

Symbol	Description and Units
c_{pa2}	specific heat of dry air leaving indoor side, J/kg·K
c_{pf}	specific heat of liquid, J/kg·K
D_n	nozzle throat diameter, mm
Δ_{pi}	measured internal static pressure difference, Pa
Δ_{pe}	measured external static pressure difference, Pa
h_{a1}	specific enthalpy of air entering indoor air-side, J/kg of dry air
h_{a2}	specific enthalpy of air leaving indoor air-side, J/kg of dry air
h_{r1}	specific enthalpy of refrigerant entering indoor side, J/kg
h_{r2}	specific enthalpy of refrigerant leaving indoor side, J/kg
K_1	latent heat of vaporization of water, J/kg (2,47 x 10^6, J/kg at 15 °C)
η	representative efficiency
P_i	power input to indoor-side compartment, W
p_n	pressure, at nozzle throat, kPa absolute
p_v	velocity pressure at nozzle throat or static pressure difference across nozzle, Pa
ϕ_c	total power input
ϕ_{fa}	fan power adjustment, W
ϕ_{lci}	latent cooling capacity, (indoor air-side data), W
ϕ_{nc}	net cooling capacity, W
ϕ_{nh}	net heating capacity, W
ϕ_{sci}	sensible cooling capacity, (air-side data), W
ϕ_{tci}	total cooling capacity, (airside data), W
ϕ_{tco}	total cooling capacity, (liquid side data), W
ϕ_{thi}	total heating capacity, (air-side data), W
ϕ_{tho}	total heating capacity, (liquid side data), W
q	measured volumetric flow rate, l/s
q_a	measured airflow rate at standard air conditions, m^3/s
q_m	air mass flow rate, kg/s
q_{ro}	refrigerant and oil mixture flow rate, m^3/s
q_s	air volume flow rate, standard air, m^3/s
q_V	air-volume flow rate, calculated, m^3/s
q_{Vi}	air volume flow rate, measured, m^3/s
q_{wc}	flow rate, liquid condensate (steam), kg/s
Re	Reynolds number
t_{a1}	temperature, air entering indoor side, dry bulb, °C
t_{a2}	temperature, air leaving indoor side, dry bulb, °C
t_{f3}	temperature, liquid entering equipment, °C
t_{f4}	temperature, liquid leaving equipment, °C
v	kinematic viscosity of air
v_n	specific volume of dry air at conditions existing at nozzle at standard barometric pressure, m^3/kg
v_n	specific volume of air at nozzle, m^3/kg of air-water vapour mixture
W_1	mass of cylinder and bleeder assembly, empty, g
W_3	mass of cylinder and bleeder assembly, with sample, g
W_5	mass of cylinder and bleeder assembly, with oil from sample, g
w_f	Liquid mass flow rate, kg/s
w_{i1}	specific humidity, air entering indoor side, kg/kg of dry air

Symbol	Description and Units
w_{i2}	specific humidity, air leaving indoor side, kg/kg of dry air
W_n	specific humidity at nozzle inlet, kg/kg of dry air
X_0	concentration of oil to refrigerant-oil mixture
X_r	mass ratio, refrigerant to refrigerant-oil mixture
Y	expansion factor

5 Rating and test conditions

5.1 Rating conditions for the determination of net capacities

5.1.1 Ratings

Ratings shall be established at the test conditions specified in 5.2, using the test procedures described in Clause 7. Ratings relating to cooling and heating capacities shall be net values (see 7.4.4 and 7.4.5), including the effects of circulating-fan heat (see 7.4.4 and 7.4.5), but excluding any supplementary heat. Energy efficiency ratios shall be based on the effective power input as defined in 3.11.

5.1.2 Power input of fans for heat pumps without duct connection

In the case of heat pumps which are not designed for duct connection and which are equipped with an integral fan, all power consumed by the fans shall be included in the effective power input to the heat pump.

5.1.3 Power input of fans for heat pumps with duct connection

5.1.3.1 If no fan is provided with the heat pump, a fan power adjustment is to be included in the effective power input to the heat pump, using Formula (1):

$$\phi_{fa} = \frac{q_a \times (\Delta_{pi})}{\eta} \tag{1}$$

where

ϕ_{fa} is the fan power adjustment, in W;

η = 0,3 by convention;

Δ_{pi} is the absolute value of the measured internal static pressure difference, in Pa;

q_a is the airflow rate at standard air conditions, in m^3/s.

This value shall be added to the heating capacity and subtracted from the cooling capacity.

5.1.3.2 If a fan is an integral part of a heat pump, only the portion of the fan power required to overcome the internal resistance shall be included in the effective power input to the heat pump. The fraction which is to be excluded from the total power consumed by the fan shall be calculated using Formula (2):

$$\phi_{fa} = \frac{q_a \times \Delta_{pe}}{\eta} \tag{2}$$

where

ϕ_{fa} is the fan power adjustment, in W;

η = 0,3 by convention;

Δ_{pe} is the measured external static pressure difference, in Pa;

q_a is the airflow rate at standard air conditions, in m^3/s.

This value shall be subtracted from the heating capacity and added to the cooling capacity.

5.1.4 Power input of liquid pumps

5.1.4.1 If no liquid pump is provided with the heat pump, a pump power adjustment is to be included in the effective power consumed by the heat pump, using Formula (3):

$$\phi_{pa} = \frac{q \times \left(\Delta_{pi}\right)}{\eta} \tag{3}$$

where

ϕ_{pa} is the pump power adjustment, in W;

η = 0,3 by convention;

Δ_{pi} is the absolute value of the measured internal static pressure difference, in Pa;

q is the measured volumetric fluid flow rate, in m^3/s.

5.1.4.2 If a liquid pump is an integral part of the heat pump, only the portion of the pump power required to overcome the internal resistance shall be included in the effective power input to the heat pump. The fraction which is to be excluded from the total power consumed by the pump shall be calculated using Formula (4):

$$\phi_{pa} = \frac{q \times \Delta_{pe}}{\eta} \tag{4}$$

where:

ϕ_{pa} is the pump power adjustment, in W;

η = 0,3 by convention;

Δ_{pe} is the measured external static pressure difference, in Pa;

q is the measured volumetric fluid flow rate, in m^3/s.

5.1.5 Airflow rates

5.1.5.1 All standard ratings shall be determined at airflow rates as described below. All airflow rates shall be expressed as cubic meters per second of standard air as defined in 3.10.

5.1.5.2 The manufacturer shall specify a single airflow rate for all tests required in this document unless automatic adjustment of airflow rate is provided by the equipment. A separate control signal output for each step of airflow rate shall be considered as an automatic adjustment.

5.1.5.3 For ducted heat pumps which have integral, non-constant airflow, single or multi-speed fans the airflow rate shall be set as specified by the manufacturer. The external static pressure shall not be less than the value defined by Table 1. If the unit is unable to attain specified airflow and has an adjustable speed, it shall be adjusted to the lowest speed that provides at least the external static defined in Table 1 at the specified airflow rate. If the external static at the rated airflow rate is less than the value defined by Table 1, then the test shall be run at the airflow achieved at the minimum external static pressure.

5.1.5.4 Ducted heat pumps which have integral constant airflow fan shall be tested at the manufacturers' specified airflow and external static pressure. Specified external static shall not be less than specified in Table 1. If the external static at the rated airflow rate is less than the value defined by Table 1, then the test shall be run at the airflow achieved at the minimum external static pressure.

Table 1 — External static pressure requirement

Standard capacity ratings kW	**Minimum external static pressure** [a] Pa
0 < Q < 8	25
8 ≤ Q < 12	37
12 ≤ Q < 20	50
20 ≤ Q < 30	62
30 ≤ Q < 45	75
45 ≤ Q < 82	100
82 ≤ Q < 117	125
117 ≤ Q < 147	150
Q > 147	175

[a] For equipment tested without an air filter installed, the minimum external static pressure shall be increased by 10 Pa.

5.1.5.5 Ducted heat pumps which do not have integral fans but which are rated for general use with a variety of air moving devices, shall be tested at the airflow rates specified by the manufacturer in the published ratings. However, the pressure drop across the indoor coil assembly and the recommended enclosures and attachment means shall not exceed 75 Pa.

5.1.5.6 If the air enthalpy method is used, non-ducted heat pumps shall be tested at the airflow rates obtained at zero external static pressure difference.

5.1.6 Liquid flow rates

5.1.6.1 General

All standard ratings shall be determined at a liquid flow rate described below, expressed as cubic meters per second.

5.1.6.2 Source side flowrate

The manufacturer shall specify a flow rate for all of the tests performed unless automatic adjustment of the liquid flow rate is provided by the equipment. A separate control signal output for each step of liquid flow rate will be considered as an automatic adjustment.

5.1.6.3 Heat pumps with integral liquid pumps shall be tested at the liquid flow rate specified by the manufacturer or that is obtained at zero external static pressure difference (within the tolerance specified in Table 11), whichever provides the lower liquid flow rate.

5.1.6.4 Heat pumps without integral liquid pumps shall be tested at the flow rate specified by the manufacturer.

5.1.7 Test liquids

5.1.7.1 The test liquid for all tests except low temperature heating tests shall be water or brine of a composition and concentration specified by the manufacturer.

5.1.7.2 The test liquid for low temperature heating tests (H1) shall be brine of a composition and concentration specified by the manufacturer.

5.1.7.3 The test liquid shall be sufficiently free of gas to ensure that the measured result is not influenced by the presence of gas.

5.2 Rating test conditions for cooling and heating capacities

5.2.1 The test conditions for the determination of cooling capacities are specified in Table 2. The test conditions for determination of heating capacities are specified in Table 3.

NOTE Previous rating conditions can be found in Annex G, Tables G.1 and G.2

5.2.2 Fixed capacity heat pumps shall be rated at standard rating conditions for one or several cooling and/or heating conditions defined by Table 2 and 3.

5.2.3 Two stage and multi-stage capacity heat pumps shall be rated at maximum capacity at standard rating conditions and at minimum capacity at application rating conditions for one or several cooling and/or heating conditions as defined by Table 2 and 3. Additional ratings may be applied at application rating conditions with different capacity levels using Tables 2 and 3.

5.2.4 Variable capacity heat pumps shall be rated at the maximum continuous capacity allowed by the controls at standard rating conditions and at the minimum capacity allowed by the controls at application rating conditions. Additional ratings may be applied at application rating conditions with different capacity levels using Tables 2 and 3.

Table 2 — Rating test conditions for the determination of cooling capacity

	C3 high source temperature	C2 medium source temperature	C1 Low source temperature
Air entering load side — dry bulb, °C — wet bulb, °C	27 19	27 19	27 19
Air surrounding unit installed indoor — dry bulb, °C — wet bulb, °C	27 19	27 19	27 19
Standard rating conditions Source side entering temperature, °C	30	20	10
Application rating conditions Source side entering temperature, °C	25	15	5
Frequency[a]	Rated	Rated	Rated
Voltage[b]	Rated	Rated	Rated

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at both voltages or at the lower of the two voltages if only a single rating is published.

Table 3 — Rating test conditions for the determination of heating capacity

	H3 high source temperature	H2 medium source temperature	H1 low source temperature
Air entering load side — dry bulb, °C — wet bulb, °C (maximum)	20 15	20 15	20 15
Air surrounding unit installed indoor — dry bulb, °C_ — wet bulb, °C (maximum)	20 15	20 15	20 15
Standard rating Conditions Source side entering temperature, °C	20	10	0
Application rating conditions Source side entering temperature, °C	25	15	5
Frequency[a]	Rated	Rated	Rated
Voltage[b]	Rated	Rated	Rated

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at both voltages or at the lower of the two voltages if only a single rating is published.

6 Performance Requirements

6.1 General

6.1.1 To comply with this document, water-to-air and brine-to-air heat pumps shall meet the applicable requirements of this document.

6.1.2 For heat pumps with capacity control, the performance requirements tests shall be conducted at the maximum capacity as determined in standard rating conditions.

6.2 Maximum operating conditions test

6.2.1 Test conditions

For maximum operating conditions tests, a single heating and/or cooling test when applicable shall be conducted at the test conditions established for the specific rating temperature range (see 5.2) specified in Tables 4 and 5.

6.2.2 Test procedures

The equipment shall be operated continuously for one hour after the specified conditions have been established at each specified voltage level.

The 110 % voltage test shall be conducted prior to the 90 % voltage test.

All power to the equipment shall be cut off for 3 min. at the conclusion of the one hour test at the 90 % voltage level and then restored for one hour.

6.2.3 Test requirements

Heat pumps shall meet the following requirements when operating at the conditions specified in Tables 4 and 5.

During the entire test, the equipment shall operate without any indication of damage.

During the test period specified in 6.2.2., the motor overload protective device may trip only during the first 5 min of operation after the shutdown period of 3 min. During the remainder of the test period, no motor overload protective device shall trip. For those models so designed that resumption of operation does not occur within the first 5 min after the initial trip, the equipment may remain out of operation for no longer than 30 min. It shall then operate continuously for the remainder of the test period.

Table 4 — Maximum cooling test conditions

Rated Temperature Range:	C3 high source temperature	C2 medium source temperature	C1 low source temperature
Air entering load side — dry bulb, °C — wet bulb, °C	32 23	32 23	32 23
Air surrounding unit — dry bulb, °C	32	32	32
Source side entering temperature, °C	40	40	40
Frequency[a]	Rated	Rated	Rated
Voltage[b]	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at both voltages or at the lower of the two voltages if only a single rating is published.

Table 5 — Maximum heating test conditions

Rating Temperature Range:	H3 high source temperature	H2 medium source temperature	H1 low source temperature
Air entering load side — dry bulb, °C	27	27	27

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at both voltages or at the lower of the two voltages if only a single rating is published.

Table 5 *(continued)*

Rating Temperature Range:	H3 high source temperature	H2 medium source temperature	H1 low source temperature
Air surrounding unit — dry bulb, °C	27	27	27
Source side entering temperature, °C	30	30	30
Frequency[a]	Rated	Rated	Rated
Voltage[b]	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.	1) 90 % and 110 % of rated voltage for equipment with a single nameplate rating, 2) 90 % of minimum voltage and 110 % of maximum voltage for equipment with dual nameplate voltage.

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at both voltages or at the lower of the two voltages if only a single rating is published.

6.3 Minimum operating conditions test

6.3.1 Test conditions

For minimum operating conditions test, a single heating and/or cooling test when applicable shall be conducted at the test conditions established for the specific applications (see 5.2.) specified in Tables 6 and 7. Heat pumps intended for use in two or more source temperature conditions shall be tested at the most stringent set of conditions specified in Tables 6 and 7.

6.3.2 Test procedures

For the minimum operating cooling test, the heat pump shall be operated continuously for a period of no less than 30 min after the specified temperature conditions have been established. For the minimum operating heating test, the heat pump shall soak for 10 min with liquid at the specified temperature circulating through the coil. The equipment shall then be started and operated continuously for 30 min.

6.3.3 Test requirements

No protective device shall trip during these tests and no damage shall occur to the equipment.

Table 6 — Minimum cooling test conditions

Rating Temperature Range:	C3 high temperature	C2 medium temperature	C1 low temperature
Air entering load side — dry bulb, °C — maximum wet bulb, °C	21 15	21 15	21 15
Air surrounding unit — dry bulb, °C	21	21	21
Source side entering temperatures, °C	10	10	10
Frequency[a]	Rated	Rated	Rated
Voltage[b]	Rated	Rated	Rated

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at the lower of the two voltages.

Table 7 — Minimum heating test conditions

Rating Temperature Range:	H3 high temperature	H2 medium temperature	H1 low temperature
Air entering load side — dry bulb, °C	15	15	15
Air surrounding unit — dry bulb, °C	15	15	15
Source side entering temperature, °C	5	5	−5
Frequency[a]	Rated	Rated	Rated
Voltage[b]	Rated	Rated	Rated

[a] Equipment with dual-rated frequencies shall be tested at each frequency.

[b] Equipment with dual-rated voltages shall be tested at the lower of the two voltages.

6.4 Enclosure sweat and condensate test

6.4.1 General

Only applicable to heat pumps designed to operate in cooling mode.

6.4.2 Test conditions

The enclosure sweat and condensate test shall be conducted in the cooling mode at the test conditions established for the specific applications specified in Table 8. All controls, fans, dampers and grilles shall be set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions to the user. Heat pumps intended for two or more source temperature conditions shall be tested at the most stringent set of conditions.

Table 8 — Enclosure sweat and condensate test conditions

	C3 high source temperature	C2 medium source temperature	C1 low source temperature
Air entering load side — dry bulb, °C — wet bulb, °C	27 24	27 24	27 24
Air surrounding unit — dry bulb, °C	27	27	27
Source side entering temperature, °C	10	10	10
Frequency[a]	Rated	Rated	Rated
Voltage[b]	Rated	Rated	Rated

[a] Equipment with dual-rated frequencies shall be tested at each frequency..

[b] Equipment with dual-rated voltages shall be tested at the lower of the two voltages.

6.4.3 Test procedures

After establishment of the specified source side temperature conditions, the heat pump shall be operated continuously for a period of four hours.

6.4.4 Test requirements

No condensed water shall drip, run or blow off the equipment's casing during the test.

7 Test methods

7.1 General

The capacity ratings shall be determined by the test methods and procedures established in this Clause 7 and the test requirements in Annex A. The total cooling and heating capacities shall be the results obtained simultaneously using the liquid enthalpy test method, in Annex E, on the source side and the indoor air enthalpy test method, in Annex C, on the load side.

The total cooling or heating capacity measured on the source side shall agree within 5 % with the total cooling or heating capacity determined from the measurements on the load side in order for the test to be valid.

Alternatively, for novel configurations where the air enthalpy test method cannot be employed, the load side total cooling and heating capacity may be measured using the refrigerant enthalpy test method as described in Annex D,.

The resulting net total cooling and net heating capacities are the total cooling and heating capacities measured on the load side and corrected from the fan power adjustment, as specified in 7.4.4 and 7.4.5.

7.2 General test requirements

The indoor and/or outdoor condition test room shall be a room or space in which the desired test conditions can be maintained within the prescribed permissible deviations.

7.3 Equipment installation

The equipment to be tested shall be installed in accordance with the manufacturer's installation instructions using recommended installation procedures, required external fans/pumps and any other accessories. No alterations to the equipment shall be made except for the attachment of required test apparatus and instruments in the prescribed manner. Where necessary, equipment shall be evacuated and charged with the type and amount of refrigerant specified in the manufacturer's instructions. Fans and pumps not connected to the unit but provided with the unit are to be installed and considered integral.

7.4 Cooling and heating capacity tests procedure

7.4.1 General

The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained, but for not less than one hour, before capacity test data are recorded.

7.4.2 Reconditioning period

The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained. Equilibrium conditions is considered obtained and maintained when all the measured quantities remain constant without having to alter the set values, for a minimum duration of 30 min, with respect to the permissible deviations given in Table 11. Periodic fluctuations of measured quantities caused by the operation of regulation and control devices are permissible, on condition the mean value of such fluctuations does not exceed the permissible deviations listed in Table 11.

7.4.3 Data collection period

For the data collection period, it is necessary to record all the meaningful data continuously. In the case of recording instruments which operate on a cyclic basis, the sequence shall be adjusted such that a complete recording is affected at least once every 30 s. The output shall be measured in the steady-state condition. The steady-state condition is considered obtained and maintained when all the measured quantities remain constant without having to alter the set values with respect to the permissible deviations given in Table 11. The duration of measurement shall be not less 30 min.

7.4.4 Net total cooling capacity

7.4.4.1 For heat pump with non-integrated load side fan, the net total cooling capacity, $\phi_{ntc,}$ is calculated as in Formula (5):

$$\phi_{ntc} = \phi_{tci} - \phi_{fa} \tag{5}$$

where

ϕ_{tci} is the total cooling capacity on the load side, in watts;

ϕ_{fa} is the fan power adjustment, in W.

7.4.4.2 For heat pumps with integrated load side fan, net total cooling capacity, $\phi_{ntc,}$, is calculated as in Formula (6):

$$\phi_{ntc} = \phi_{tci} + \phi_{fa} \tag{6}$$

where

ϕ_{tci} is the total cooling capacity on the load side, in W;

ϕ_{fa} is the fan power adjustment, in W.

7.4.5 Net heating capacity

7.4.5.1 For heat pumps with non-integrated load side fan, the net heating capacity, $\phi_{nh,}$ is calculated as in Formula (7):

$$\phi_{nh} = \phi_{hi} + \phi_{fa} \tag{7}$$

where

ϕ_{hi} is the heating capacity on the load side, in W;

ϕ_{fa} is the fan power adjustment, in W.

7.4.5.2 For heat pumps with integrated load side fan, net heating capacity, ϕ_{nh}, is calculated as in Formula (8):

$$\phi_{nh} = \phi_{hi} - \phi_{fa} \tag{8}$$

where

ϕ_{hi} is the heating capacity on the load side, in W;

ϕ_{fa} is the fan power adjustment, in W.

7.5 Uncertainties of measurement

The uncertainties of measurement shall not exceed the values specified in Table 10. For standard rating condition, the rating capacities shall be determined within a maximum uncertainty of 5 % from each of the source side and 10 % from the air load side, independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids.

7.6 Data to be recorded

The data to be recorded during the test are included in Table 9.

Table 9 — Data to be recorded

No.	Data	Unit
1	Date	
2	Observer(s)	
3	Barometric pressure	kPa
4	Equipment nameplate data	
5	Time data was recorded	
6	Total power input to equipment	W
7	Applied voltage(s)	V
8	Frequency	Hz
9	External static pressure difference, air (for units with integral fans)	Pa
10	Internal static pressure difference, air (for units without integral fans)	Pa
11	Fan speed(s), (if adjustable)	r/min
12	Dry-bulb temperature of air entering equipment	°C
13	Wet-bulb temperature of air entering equipment	°C
14	Dry-bulb temperature of air leaving equipment	°C

Table 9 *(continued)*

No.	Data	Unit
15	Wet-bulb temperature1 of air leaving equipment	°C
16	Volume flow rate of air and all relevant measurements for its calculations	m^{3}.s-1
17	Temperature of liquid entering source heat exchanger	°C
18	Temperature of liquid leaving source heat exchanger	°C
19	Liquid flow rate of source heat exchanger	m^{3}.s-1
20	External static pressure difference, liquid (for units with integral pumps)	Pa
21	Internal static pressure difference, liquid (for units without integral pumps)	Pa
22	Temperature of air surrounding	°C

7.7 Uncertainties of measurements and permissible deviations for steady-state cooling and heating capacity tests

The uncertainties of measurement are listed in Table 10. The allowable variation during the capacity test reading is listed in Table 11. The maximum permissible variation of any observation during the performance tests is listed in Table 12.

Table 10 — Uncertainties of measurement for indicated values

Measured quantity	Uncertainty of measurement[a]
Water:	0,15 K
— temperature	0,15 K
— temperature difference	1 %
— volume flow	1 kPa for pressure ≤ 20 kPa
— static pressure difference	5 % for pressure >20 kPa
Air:	0,2 K
— dry-bulb temperature	0,4 K
— wet-bulb temperature	5 %
— volume flow	5 Pa for pressure ≤100 Pa
— static pressure difference	5 % for pressure >100 Pa
Electrical measurements	0,5 %
Time	0,2 %
Mass	1,0 %
Speed	1,0 %

NOTE Uncertainty of measurement comprises, in general, many components. Some of these components may be estimated on the basis of the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. Estimates of other components can be based on experience or other information. ISO/TS 16491 is available as an appropriate guidance.

[a] Uncertainty of measurement is an estimate characterizing the range of values within which the true value of the measurement lies, based on a 95 % confidence interval (see ISO/IEC Guide 98-3).

Table 11 — Permissible deviations in capacity test readings

Reading	Variations of arithmetical mean values from specified test conditions	Maximum variation of individual readings from specified test conditions
Liquid temperature entering	± 0,2 K	± 0,5 K
Liquid temperature leaving	± 0,2 K	± 0,5 K[d]
Temperature of air entering the indoor-side[c]: — dry-bulb — wet-bulb	± 0,3 K ± 0,2 K[a]	± 0,5 K ± 0,3 K[a]
Temperature of air leaving the indoor-side[c]: — dry-bulb wet-bulb	—	± 0,5 K[d] ± 0,3 K[a,d]
Temperature of air surrounding unit: — dry-bulb wet-bulb	± 0,3 K ± 0,2 K[a]	± 0,5 K ± 0,3 K[a]
Voltage	± 1 %	± 2 %
External resistance to liquid flow at zero static	± 10 kPa	± 20 kPa
Liquid volume flow rate	±1 %	± 2 %
Air volume flow rate[b]	±5 %	± 10 %
External resistance to airflow	≤100 Pa ± 5 Pa >100 Pa ± 5 %	≤100 Pa ± 10 Pa >100 Pa ± 10 %

[a] Not applicable for heating tests.

[b] Only applies to the indoor air enthalpy method. The test condition is defined as the measured arithmetical mean of airflow taken within the first 5 min of the data collection period.

[c] Only applies to the capacity tests

[d] The tolerance represents the greatest permissible difference between the maximum and minimum observations during the test.

The maximum permissible variations of the test observations from the test conditions are shown in Table 12.

Table 12 — Permissible deviations in performance test readings

Quantity measured	Maximum variation of individual readings from stated performance test conditions
For minimum operating conditions test: — air temperatures — liquid temperatures	 +1.0 K +0,6K
For maximum operating conditions test: — air temperatures — liquid temperatures	 −1,0 K −0,6 K
For other tests: — air temperatures — liquid temperatures	 ± 1,0 K ± 0,6 K

7.8 Test results

For given test conditions, the capacity test results shall include the following, in in Table 13, as applicable:

Table 13 — Capacity test result data

Number	Data	Unit
1	total cooling capacity	W
2	heating capacity	W
3	measured power input to equipment	W
4	fan power adjustment	W
5	liquid pump power adjustment	W
6	effective power input to equipment or power inputs to all equipment	W
7	net total cooling capacity	W
8	net heating capacity	W
9	energy efficiency ratio	W
10	coefficient of performance, watts per watts	W / W

8 Marking provisions

8.1 Nameplate requirements

Each water-to-air and brine-to-air heat pump, whether composed of a single package or separate assemblies, shall have a durable nameplate, firmly attached to each separate assembly in a location accessible for reading.

8.2 Nameplate information

The nameplate shall provide the following minimum information in addition to the information required in international safety standards.

a) Manufacturer's name or trademark. (The manufacturer is considered to be the firm identified on the nameplate).

b) Distinctive type or model designation and serial number.

c) Standard rating capacity (see 7.4). Equipment rated for more than one source side temperature conditions shall state standard ratings capacities for both heating and cooling, as appropriate, for each temperature condition.

d) Rated voltage(s).

e) Rated frequency(ies).

f) Refrigerant designation and refrigerant mass charge (see 8.4).

8.3 Designation of standard ratings capacity

The designation of standard rating capacity shall be established in such a way that the source side media are indicated (A = air, W = water, and B = brine), together with their temperatures, followed by their standard capacities in kilowatts. The standard capacities rating shall be stated to the nearest kilowatt (1 kW = W/1000). The first figure shall be the high liquid source temperature of the heat pump; the second figure shall be the medium liquid temperature of the heat pump; the last figure shall be the low liquid temperature of the heat pump.

EXAMPLE:

Cooling: A27 - W30/W20/B10   10/11/12 kW

Heating: A20 - W20/W10/B0 10/9/8 kW

8.4 Refrigerant designation

The refrigerant designation shall be in accordance with ISO 817.

9 Publication of ratings

9.1 Published ratings

Ratings at standard and application rating conditions shall be published for the net heating capacity, the net total cooling capacity, energy efficiency ratio, and coefficient of performance, as appropriate, for each heat pump rated in accordance with this document for each intended source side temperature condition. These ratings shall be based on data obtained in accordance with the testing procedures specified in this document.

The values of the rating capacities shall be expressed in kilowatts (1 kW = W/1 000), rounded to three significant figures.

The values of energy efficiency ratios and coefficients of performance shall be rounded to the nearest 0,05.

Each capacity rating shall be followed by the corresponding voltage and frequency ratings.

Standard ratings capacities are representative of equipment operating at zero external static pressure for both air and liquid flows. To derive performance of specific applications see Annex F.

9.2 Additional ratings

Additional ratings may be published based on conditions other than those specified as standard and application rating conditions if they are clearly specified and the data are determined by the methods specified in this document, or by analytical methods which are verifiable by the test methods prescribed in Clause 7, and are accompanied by the standard and application net capacity ratings, energy efficiency ratios, and the coefficients of performance.

Annex A
(normative)

Test requirements

A.1 General test room requirements

The test room shall be a room or space in which the desired test conditions can be maintained within the permissible deviations and of sufficient volume for the unit. It is recommended that air velocities in the vicinity of the equipment under test do not exceed 2,5 m/s.

A.2 Equipment installation

A.2.1 The equipment to be tested shall be installed in accordance with the manufacturer's installation instructions using recommended installation procedures and accessories. If the equipment is capable of being installed in multiple positions, all tests shall be conducted in a position specified in the manufacturer's installation instructions. In all cases, the manufacturer's recommendations with respect to distances from adjacent walls, amount of extension through walls, etc. shall be followed.

A.2.2 Ducted equipment rated at less than 8 kW and intended to operate at an ESP, external static pressure of less than 25 Pa shall be tested at free delivery of air.

A.2.3 No other alterations to the equipment shall be made except for the attachment of the required test apparatus and instruments in the prescribed manner.

A.2.4 If necessary, the equipment shall be evacuated and charged with the type and amount of refrigerant specified in the manufacturer's instructions.

The line diameters, insulation, details of installation, evacuation and charging shall be in accordance with the manufacturer's published recommendations.

A.2.5 In the case of heat pumps consisting of separate matched assemblies, the following installation procedures shall be followed.

a) Each refrigerant line shall be installed in accordance with the manufacturer's instructions with the maximum stated length or 7,5 m, whichever is shorter. If the interconnecting tubing is furnished as an integral part of the equipment and not recommended for cutting the length, the equipment shall be tested with the complete length of tubing furnished.

b) The lengths shall be actual lengths, not equivalent lengths, and no account shall be taken of the resistance provided by bends, branches, connecting boxes or other fittings used in the installation for the test piece. The length of the connecting tubing shall be measured from the enclosure of the indoor unit to the enclosure of the outdoor unit.

c) The lines shall be installed without any significant difference in elevation (not more than 2,5 m).

d) Not less than 40 % of the total length of the interconnecting tubing shall be exposed to the outdoor conditions with the rest of the tubing insulation to the manufacturer instructions exposed to the indoor conditions.

A.3 Static pressure measurements across indoor coil — Equipment with a fan and a single outlet

A.3.1 A short plenum shall be attached to the outlet of the equipment. This plenum shall have cross-sectional dimensions equal to the dimensions of the equipment outlet. A static pressure tap shall be added at the centre of each side of the discharge plenum, if rectangular, or at four evenly distributed locations along the circumference of an oval or round plenum. These four static pressure taps shall be manifolded together. The minimum length of the discharge plenum and the location of the static pressure taps relative to the equipment outlet shall be as shown in Figure A.1, if testing a split-system unit, and as shown in Figure A.2, if testing a single-package unit.

A.3.2 For inlet ducted units, a short plenum should be attached to the inlet of the equipment. If used, the inlet plenum shall have cross-sectional dimensions of the equipment inlet. In addition, four static pressure taps shall be added and manifolded together. This plenum should otherwise be constructed as shown for the inlet plenum in Figure A.1, if testing a single-package unit, and as shown in Figure A.2, if testing a split system. Never use an inlet plenum for non-ducted units.

NOTE Figure A.3 is referenced here for guidance even though it specifically applies to ducted units tested without an indoor fan.

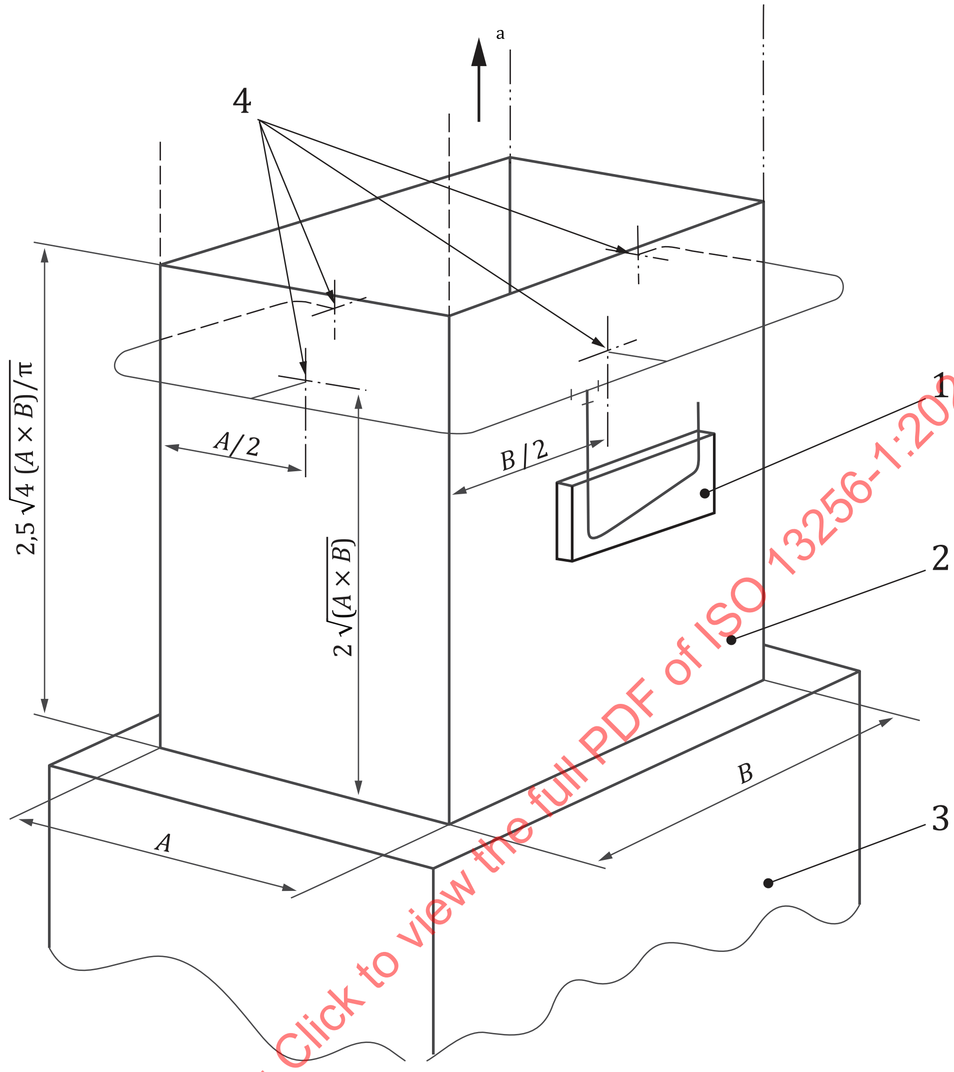
A.4 Equipment with fans and multiple outlets or multiple indoor units

A.4.1 Equipment with multiple outlet duct connections or multiple indoor units shall have a short plenum attached to each outlet connection or indoor unit, respectively. Each of these short plenums shall be constructed as described in A.3.1, including the static pressure taps. All outlet plenums shall discharge into a single common duct section. For the purpose of equalizing the static pressure in each plenum, an adjustable restrictor shall be located in the plane where each outlet plenum enters the common duct section. Multiple blower units employing a single discharge duct connection flange shall be tested with a single outlet plenum in accordance with A.3.1. Any other test plenum arrangements shall not be used except to simulate duct designs specifically recommended by the equipment manufacturer.

A.4.2 A short plenum should be attached to the inlet of each inlet duct connection or indoor unit. Each of these short plenums shall be constructed as described in A.3.2, including static pressure taps.

A.5 Equipment without a fan and with a single outlet

For an indoor coil that does not incorporate a fan, a short plenum shall be attached to both the inlet and the outlet of the equipment. These plenums shall have cross-sectional dimensions equal to the respective dimensions of the equipment inlet and outlet. A static pressure tap shall be added at the centre of each side of each plenum, if rectangular, or at four evenly distributed locations along the circumference of oval or round plenums. For each plenum, the four static pressure taps shall be manifolded together. The minimum length of the plenums and the location of the static pressure taps relative to the equipment inlet and outlet shall be as shown in Figure A.3.

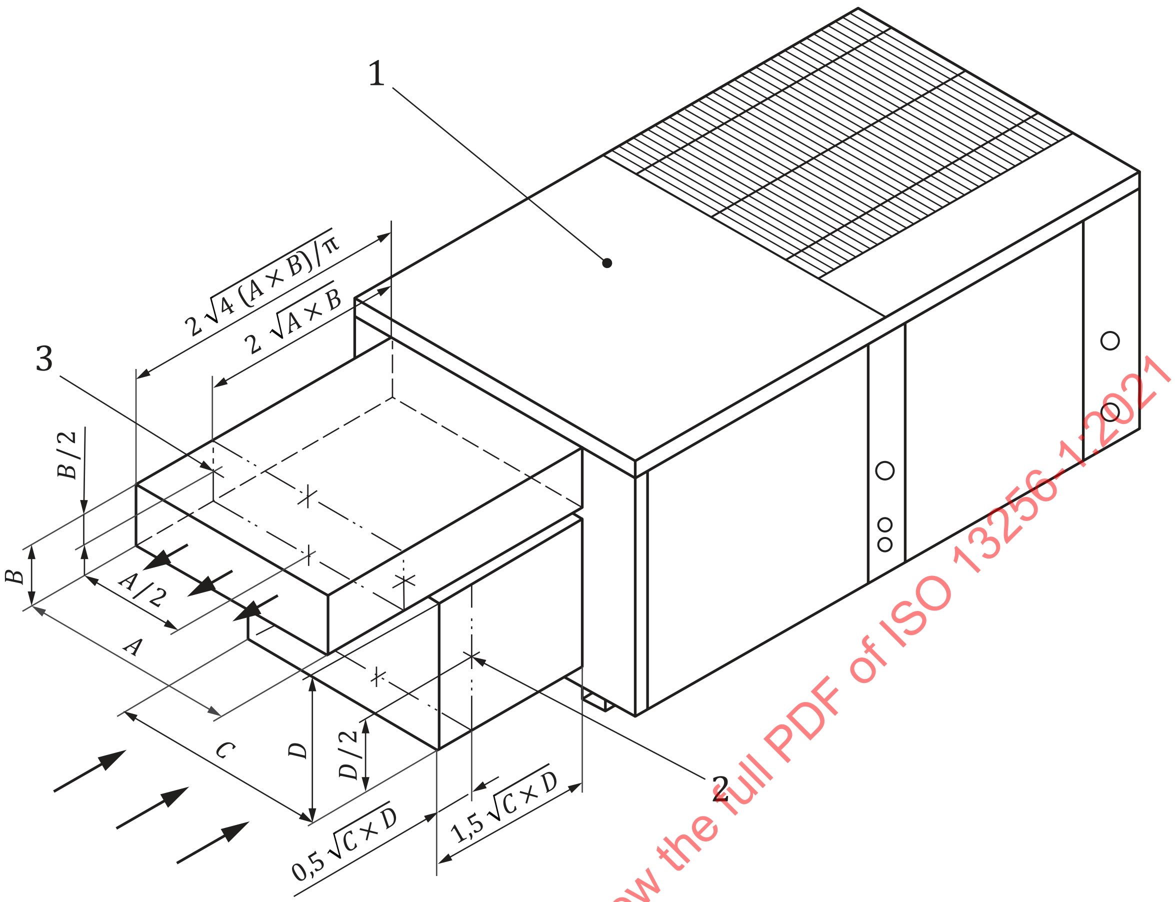


Key

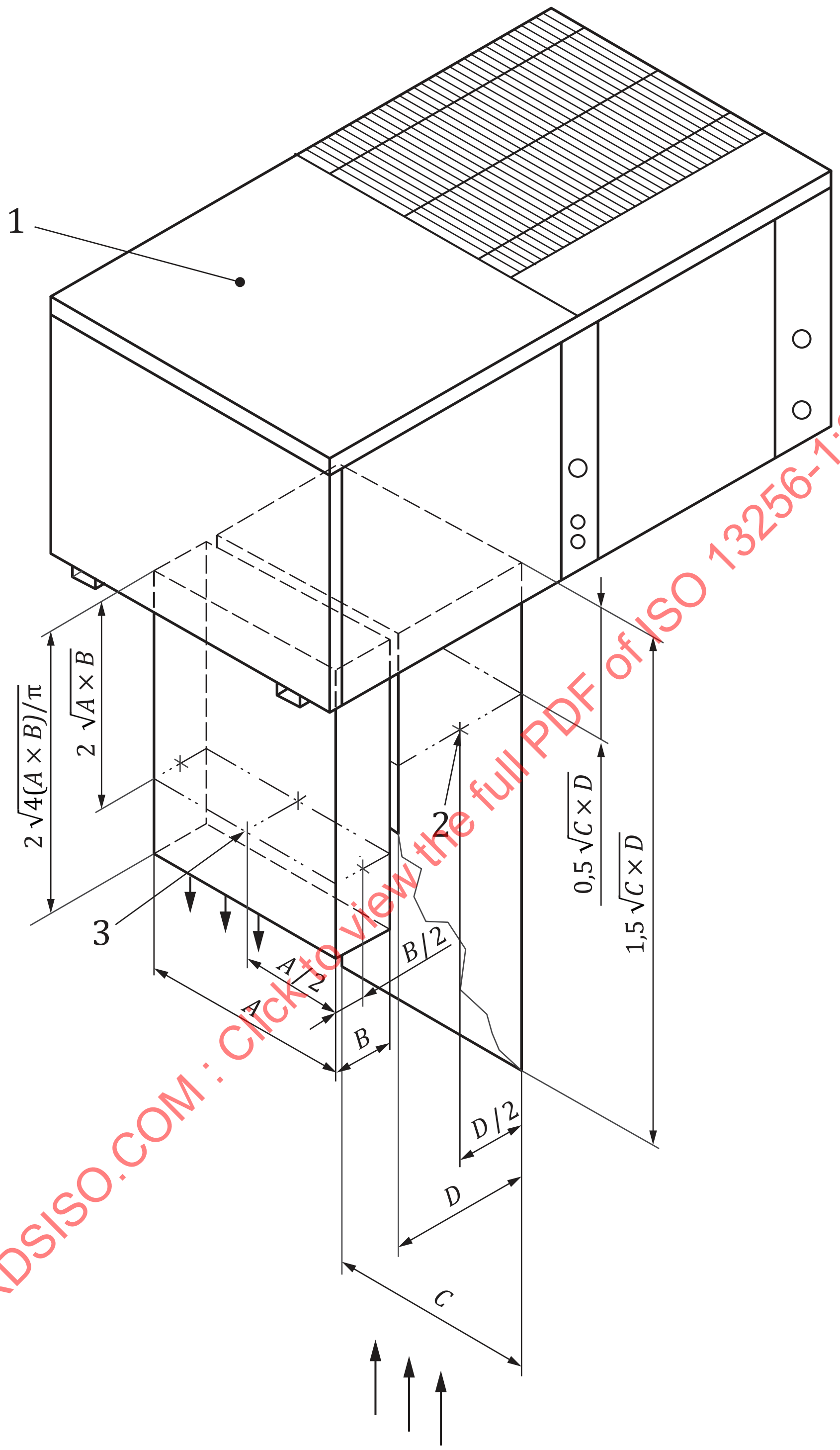
1 manometer
2 exhaust plenum
3 equipment under test
4 static pressure taps
[a] To airflow-measuring apparatus.

NOTE *A* and *B* are dimensions of the equipment under test.

Figure A.1 — ESP measurement — Split system



a)



b)

Key

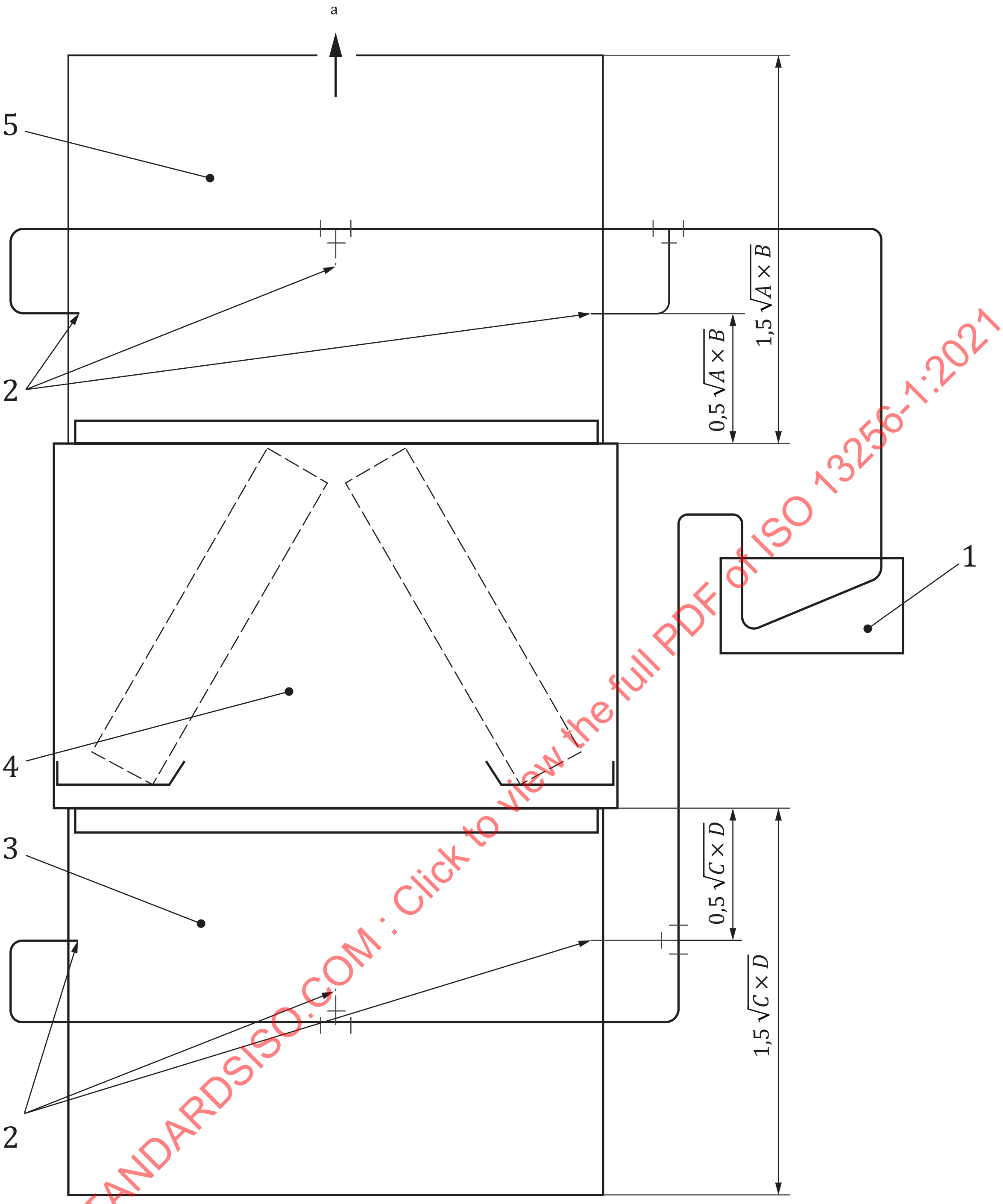
1 equipment under test – single-package unit

2 static pressure tap, inlet (4 required)

3 static pressure tap, outlet (4 required)

NOTE For circular ducts with diameter d, substitute $\pi d^2/4$ for (A × B) or (C × D).

Figure A.2 — ESP measurements — Single package



Key

1	manometer	4	coil section
2	outlet pressure taps	5	outlet duct
3	inlet duct	a	To airflow measuring apparatus.

NOTE 1 *A* and *B* are outlet dimensions; *C* and *D* are inlet dimensions.

NOTE 2 For circular ducts with diameter *D*, substitute $\pi D_i^2/4$ for ($C \times D$) and $\pi D_o{}^2/4$ for ($A \times B$), where D_i is inlet duct diameter and D_o is the outlet duct diameter.

NOTE 3 The length of the inlet duct, $1{,}5\sqrt{C \times D}$, is a minimum dimension. For more precise results, use $4\sqrt{C \times D}$.

Figure A.3 — Air static pressure drop measurement over the coil for a coil-only unit

Annex B
(informative)

Airflow measurement

B.1 Airflow determination

B.1.1 Airflow should be measured using the apparatus and testing procedures given in this annex.

B.1.2 Airflow quantities are determined as mass flow rates. If airflow quantities are to be expressed for rating purposes in volume flow rates, such ratings should state the conditions (pressure, temperature and humidity) at which the specific volume is determined.

B.2 Airflow and static pressure

The area of a nozzle, A_n, should be determined by measuring its diameter to an accuracy of ± 0,2 % in four locations approximately 45° apart around the nozzle in each of two places through the nozzle throat, one at the outlet and the other in the straight section near the radius.

B.3 Nozzle apparatus

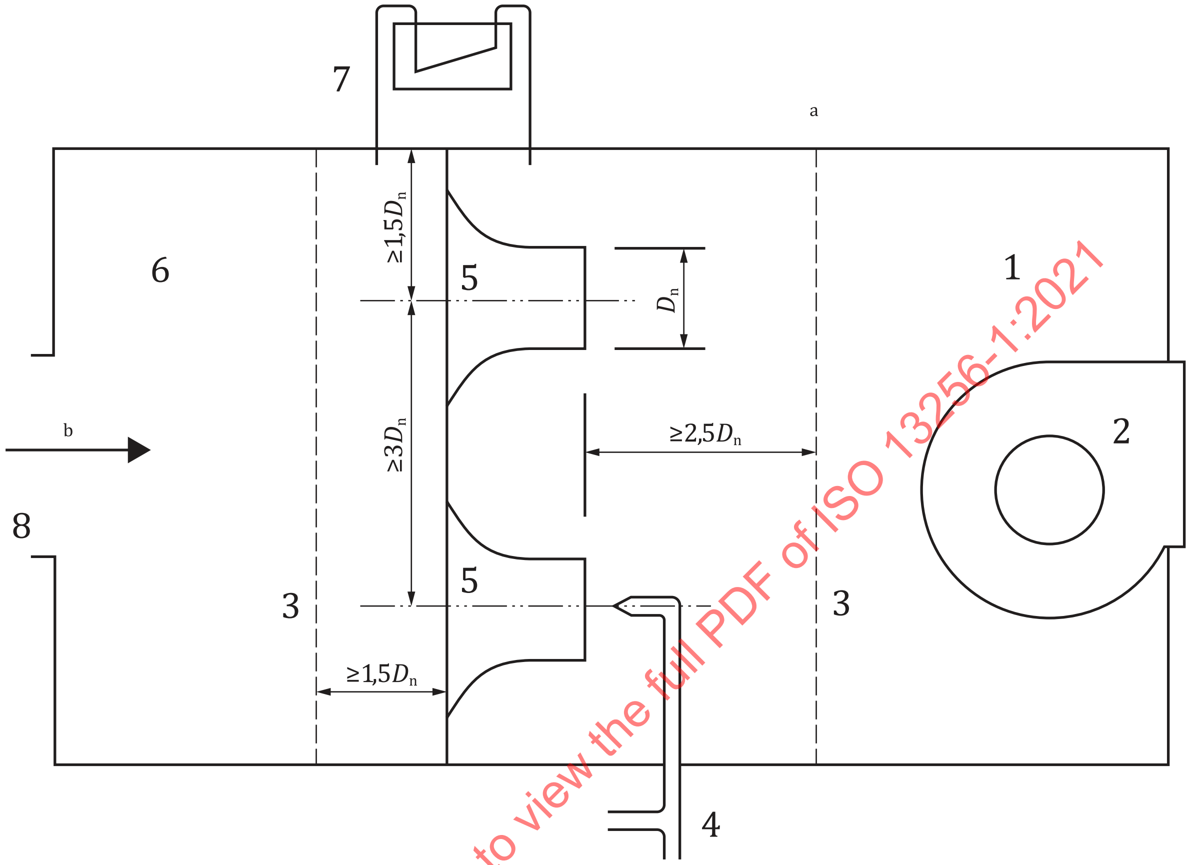
B.3.1 Nozzle apparatus, consisting of a receiving chamber and a discharge chamber separated by a partition in which one or more nozzles are located (see Figure B.1). Air from the equipment under test is conveyed via a duct to the receiving chamber, where it passes through the nozzle(s) and is then exhausted to the test room or channelled back to the equipment's inlet.

The nozzle apparatus and its connections to the equipment's inlet should be sealed such that air leakage does not exceed 1,0 % of the airflow rate being measured.

The centre-to-centre distance between nozzles in use should be not less than 3 times the throat diameter of the larger nozzle, and the distance from the centre of any nozzle to the nearest discharge- or receiving- chamber side wall should not be less than 1,5 times the nozzle throat diameter.

B.3.2 Diffusers, installed in the receiving chamber (at a distance at least 1,5 times the largest nozzle throat diameter, D_n) upstream of the partition wall and in the discharge chamber (at a distance at least 2,5 times the largest nozzle throat diameter, D_n) downstream of the exit plane of the largest nozzle.

B.3.3 Exhaust fan, capable of providing the desired static pressure at the equipment's outlet. The exhaust fan should be installed in one wall of the discharge chamber and be equipped with a means of varying its capacity.



Key

1 discharge chamber

2 exhaust fan

3 diffusion baffle

4 pitot tube (optional)

5 nozzle

6 receiving chamber

7 apparatus for differential pressure measurement

8 adaptor duct (see B.5.1)

D_n nozzle throat diameter

[a] Diffusion baffles should have uniform perforations, with approximately 40 % of free area.

[b] Airflow.

Figure B.1 — Airflow measuring apparatus

B.3.4 Manometers, for measuring the static pressure drop across the nozzle(s).

One end of the manometer should be connected to a static pressure tap located flush with the inner wall of the receiving chamber and the other end to a static pressure tap located flush with the inner wall of the discharge chamber or, preferably, several taps in each chamber should be connected to several manometers in parallel or manifolded to a single manometer. Static pressure connections should be located so as not to be affected by airflow. Alternatively, the velocity head of the air stream leaving the nozzle(s) may be measured by a Pitot tube as shown in Figure B.1, but when more than one nozzle is in use, the Pitot tube reading should be determined for each nozzle.

B.3.5 Means for determining the air density at the nozzle throat.

B.3.5.1 The throat velocity of any nozzle in use should be not less than 15 m/s or more than 35 m/s.

B.3.5.2 Nozzles should be constructed in accordance with Figure B.2 and applied in accordance with the provisions of B.3.5.3 and B.3.5.4.

B.3.5.3 The nozzle discharge coefficient, C_d, for the construction shown in Figure B.2, which has a throat length to throat diameter ratio of 0,6, may be determined using Formula (B.1):

$$C_d = 0{,}998\,6 - \frac{7{,}006}{\sqrt{Re}} + \frac{134{,}6}{Re} \quad \text{(B.1)}$$

for Reynolds numbers, *Re*, of 12 000 and above.

The Reynolds number is defined as in Formula (B.2):

$$Re = \frac{v_n D_n}{\nu} \quad \text{(B.2)}$$

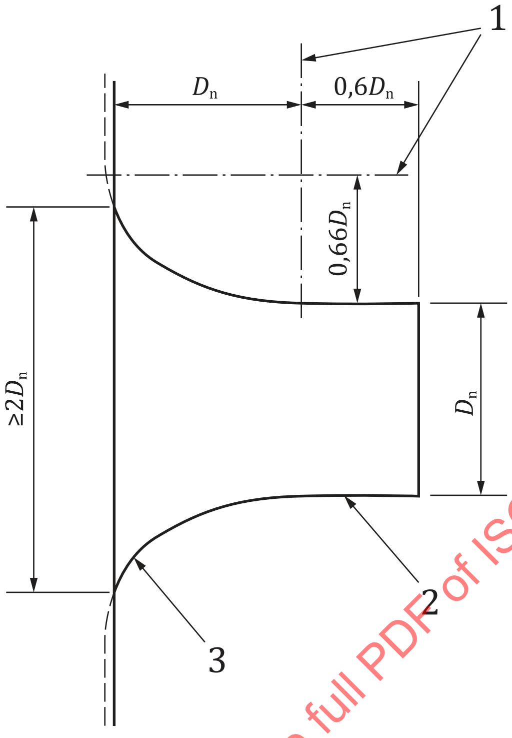
where

v_n is the airflow velocity at the throat of the nozzle;

D_n is the diameter of the throat of the nozzle;

ν is the kinematic viscosity of air.

B.3.5.4 Nozzles may also be constructed in accordance with appropriate national standards, provided they can be used in the apparatus described in Figure B.1 and they result in equivalent accuracy.



Key

1 axes of ellipse

2 throat section

3 elliptical approach

D_n nozzle throat diameter, in metres

Figure B.2 — Airflow measuring nozzle

B.4 Static pressure measurements

B.4.1 The pressure taps should consist of (6,25 ± 0,25) mm diameter nipples soldered to the outer plenum surfaces and centred over 1 mm diameter holes through the plenum. The edges of these holes should be free of burrs and other surface irregularities.

B.4.2 The plenum and duct section should be sealed to prevent air leakage, particularly at the connections to the equipment and the air measuring device, and should be insulated to prevent heat leakage between the equipment outlet and the temperature-measuring instruments.

B.5 Discharge airflow measurements

B.5.1 The outlet or outlets of the equipment under test should be connected to the receiving chamber by adaptor ducting of negligible air resistance, as shown in Figure B.1.

B.5.2 To measure the static pressure of the receiving chamber, a manometer should have one side connected to one or more static pressure connections located flush with the inner wall of the receiving chamber.

B.6 Indoor-side airflow measurements

B.6.1 The following readings should be taken:

a) barometric pressure;

b) nozzle dry- and wet-bulb temperatures or dewpoint temperatures;

c) static pressure difference at the nozzle(s) or, optionally, nozzle velocity pressure;

B.6.2 The air mass flow rate, q_m, through a single nozzle is determined using Formula (B.3):

$$q_m = YxC_d xA_n \sqrt{\frac{2p_v}{V_n^{'}}} \tag{B.3}$$

where

Y is the expansion factor;

C_d is the nozzle discharge coefficient;

A_n is the nozzle area, m²;

p_v is the velocity pressure at nozzle throat or static pressure difference across nozzle, Pa;

$V_n^{'}$ is the specific volume of air at nozzle, m³/kg of air water-vapour mixture.

The expansion factor, Y, is obtained using Formula (B.4):

$$Y = 0{,}452 + 0{,}548\alpha \tag{B.4}$$

where

α is the pressure ratio.

The pressure ratio, α, is obtained using Formula (B.5):

$$\alpha = 1 - \frac{p_v}{p_n} \tag{B.5}$$

where

p_v is the velocity pressure at nozzle throat or static pressure difference across nozzle, Pa;

p_n is the pressure at nozzle throat. kPa absolute.

Air volume flow rate, q_V, through a single nozzle is determined using Formula (B.6):

$$q_V = YxC_d xA_n \sqrt{2p_v V_n^{'}} \tag{B.6}$$

where

Y is the expansion factor;

C_d is the nozzle discharge coefficient;

A_n is the nozzle area, m²;

p_v is the velocity pressure at nozzle throat or static pressure difference across nozzle, Pa;

V_n' is the specific volume of air at nozzle, m³/kg of air water-vapour mixture.

where v'_n is calculated using Formula (B.7):

$$v_n' = \frac{v_n}{1+W_n} \tag{B.7}$$

where

v_n is the specific volume of dry air at conditions existing at the nozzle at standard barometric pressure, m³/kg;

W_n is the specific humidity at the nozzle inlet, kg/kg of dry air.

Air volume flow rate expressed in terms of standard air q_s is calculated by Formula (B.8)

$$q_s = \frac{q_v}{1{,}204 v_n'} \tag{B.8}$$

where

v_n' is the specific volume of air at nozzle, m³/kg of air water-vapour mixture;

q_v is the air volume flow rate calculated, m³/s.

B.6.3 Airflow through multiple nozzles may be calculated in accordance with B.6.2, except that the total flow rate is then the sum of the q_m or q_V values for each nozzle used.

B.7 Ventilation, exhaust and leakage airflow measurements — Calorimeter test method

B.7.1 Ventilation, exhaust and leakage airflows should be measured using apparatus similar to that illustrated in Figure B.3 with the refrigeration system in operation and after condensate equilibrium has been obtained.

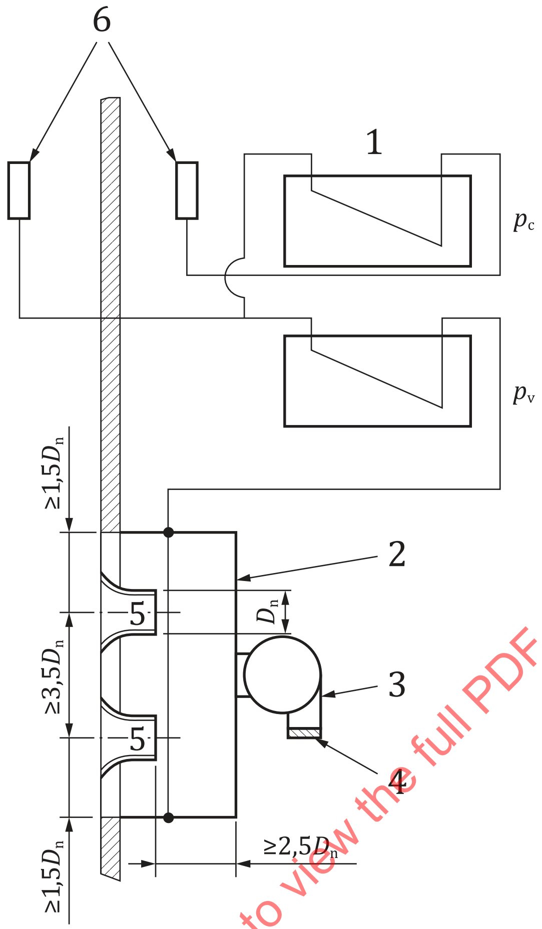
B.7.2 With the equalizing device adjusted for a maximum static pressure differential between the indoor-side and outdoor-side compartments of 1 Pa, the following readings should be taken:

d) barometric pressure;

e) nozzle wet- and dry-bulb temperatures;

f) nozzle velocity pressure.

B.7.3 Airflow values should be calculated in accordance with B.6.2.



Key

1 pressure manometers
2 discharge chamber
3 exhaust fan
4 damper
5 nozzle
6 pick-up tube
D_n nozzle throat diameter, in metres
p_c compartment equalization pressure
p_v nozzle velocity pressure

Figure B.3 — Pressure-equalizing device

Annex C
(normative)

Indoor air enthalpy test method

C.1 General

In the air enthalpy method, capacities are determined from measurements of entering and leaving wet- and dry-bulb temperatures and the associated airflow rate.

C.2 Application

C.2.1 Air leaving the equipment under the test shall lead directly to the discharge chamber. If a direct connection cannot be made between the equipment and the discharge chamber, a short plenum shall be attached to the equipment. In this case, the short plenum shall have the same size as the discharge opening of the equipment or shall be constructed so as not to prevent the leaving air from expanding. The cross-sectional area of the airflow channel through the discharge chamber shall be such that the average air velocity is less than 1,25 m/s against the airflow rate of the equipment under test. The static pressure difference between the discharge chamber and the intake opening of the equipment under test shall be zero. An example of the discharge chamber test set-up is shown in Figure C.1.

Airflow measurements should be made in accordance with the provisions specified in Annex B.

NOTE Additional guidance can be found in ISO 3966 and ISO 5167-1, as appropriate, and in the provisions of this annex.

C.2.2 When conducting cooling or steady-state heating capacity tests using the indoor air enthalpy test method, the additional test permissible deviations given in Table C.1 shall apply.

Table C.1 — Permissible deviations during steady-state cooling and heating capacity tests that only apply when using the indoor air enthalpy method

Reading	Variations of arithmetical mean values from specified test conditions[b]		Maximum variation of individual readings from specified test conditions[b]	
	≤ 100 Pa	>100 Pa	≤ 100 Pa	>100 Pa
External resistance to indoor airflow	± 0,5 Pa	± 5 %	± 1,0 Pa	± 10 %

[a] The tolerance represents the greatest permissible difference between the maximum and minimum observations during the test.

[b] The test condition is defined as the measured arithmetical mean of static pressure taken within the first 5 minutes of the data collection period.