
**Cigarettes — Determination of
ventilation — Definitions and
measurement principles**

*Cigarettes — Détermination du taux de ventilation — Définitions et
principes de mesurage*

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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 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 126, *Tobacco and tobacco products* Subcommittee SC 1, *Physical and dimensional tests*.

This third edition cancels and replaces the second edition (ISO 9512:2002), which has been technically revised. The main changes compared to the previous edition are as follows:

- introduction of the prime designator (Q') to indicate a component of the ventilation flow that is measured on the inlet side to the cigarette or standard and that is converted to a volumetric flow at the outlet side (see 3.5);
- addition of a typical calibration process for ventilation standards (see A.3.2 j);
- updated product repeatability and reproducibility statistics (see Clause 11);
- editorial changes in accordance with current guidelines.

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.

Cigarettes — Determination of ventilation — Definitions and measurement principles

1 Scope

This document specifies a method for the determination of ventilation which is applicable to cigarettes.

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 3308, *Routine analytical cigarette-smoking machine — Definitions and standard conditions*

ISO 3402:1999, *Tobacco and tobacco products — Atmosphere for conditioning and testing*

ISO 6565, *Tobacco and tobacco products — Draw resistance of cigarettes and pressure drop of filter rods — Standard conditions and measurement*

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

ventilation

aspiration of atmospheric air into an unlit cigarette other than through its *front area* (3.2)

Note 1 to entry: Dilution is the effect of ventilation on the smoke concentration of a lit cigarette.

3.2

front area

end of a cigarette which is intended to be lit

3.3

total airflow rate

Q

volumetric flow rate of air leaving the mouth end of an unlit cigarette which is encapsulated in a measurement device having an insertion depth as defined in ISO 3308

Note 1 to entry: Under standard test conditions, $Q = 17,5$ ml/s.

3.4

generator for total airflow

device to maintain a constant volumetric flow rate at the exit of the mouth end of a cigarette when encapsulated in a measurement head having an insertion depth

3.5 ventilation airflow

flow of air entering an unlit cigarette other than through the *front area* (3.2) of the cigarette

Note 1 to entry: The volumetric flow rate of the ventilation airflow is normalized to the negative pressure at the mouth end of the unlit cigarette, created by the draw resistance of the cigarette when encapsulated in a measurement device having an insertion depth as defined in ISO 3308.

Note 2 to entry: In this document, a measured volumetric flow rate is referred to as Q , or Q_{SUFFIX} where a component of the ventilation flow is denoted (see 3.7 and Figure 1). Ventilation flows are measured on the inlet side to the cigarette (see Figure 2) and are denoted with a prime (e.g. Q'_{SUFFIX}) after conversion to the corresponding volumetric flow rate at the outlet to the cigarette.

Note 3 to entry: The *total airflow rate* (3.3) is defined and measured at the outlet to the cigarette and is therefore denoted as Q .

3.6 total ventilation

total volumetric flow rate of air that has entered the cigarette other than through the *front area* (3.2) of the cigarette, normalized as defined in 3.5, when the unlit cigarette is encapsulated in a measurement device having an insertion depth as defined in ISO 3308

3.7 degree of ventilation

ratio, expressed as a percentage, of the *ventilation airflow* (3.5) to the total airflow

Note 1 to entry: See Figures 1 b), c) and d).

Note 2 to entry: The degree of total ventilation comprises the airflow as defined in 3.6.

Note 3 to entry: The *total ventilation* (3.6) can be divided into the following components of ventilation airflow, with the degree of each being expressed as a percentage of the total airflow.

3.7.1 filter ventilation

Q'_F
volumetric flow rate of air that has entered the cigarette through the filter joining paper (tipping paper) between the covered part of the mouth end and the beginning of the tobacco rod, normalized as defined in 3.5

Note 1 to entry: See Figure 1 b).

Note 2 to entry: In practical instrumentation, the filter ventilation airflow rate is expected to be approximately equal to the *tipping-paper ventilation* (3.7.5) airflow rate provided that any ventilation holes are not occluded.

3.7.2 paper ventilation

Q'_P
volumetric flow rate of air that has entered the cigarette through the envelope covering the whole length of the tobacco rod, normalized as defined in 3.5

Note 1 to entry: See Figure 1 b).

Note 2 to entry: In practical instrumentation, the paper ventilation airflow rate is expected to be approximately equal to the cigarette-paper ventilation airflow rate provided that any ventilation holes are not occluded.

3.7.3**butt ventilation** Q'_B

volumetric flow rate of air that has entered the cigarette between the covered part of the mouth end of the cigarette and the position defined by the butt length (as defined in ISO 3308) appropriate to the cigarette, normalized as defined in [3.5](#)

Note 1 to entry: See [Figure 1](#) c).

3.7.4**burnable tobacco rod ventilation** Q'_R

volumetric flow rate of air that has entered the cigarette through its paper between the position defined by the butt length appropriate to the cigarette and the end of the cigarette which would be lit, normalized as defined in [3.5](#)

Note 1 to entry: See [Figure 1](#) c).

3.7.5**tipping-paper ventilation** Q'_M

volumetric flow rate of air that has entered the cigarette through the filter joining paper (tipping paper) between the covered part of the mouth end and the tobacco rod end of the tipping paper, normalized as defined in [3.5](#)

Note 1 to entry: See [Figure 1](#) d).

3.7.6**cigarette-paper ventilation**

envelope ventilation

 Q'_C

volumetric flow rate of air that has entered the cigarette through the cigarette paper between the end of cigarette which would be lit and the frontal end of the tipping paper, normalized as defined in [3.5](#)

Note 1 to entry: See [Figure 1](#) d).

4 Principle

Air is drawn, at a constant flow rate, in the standard smoking direction through an unlit cigarette. The individual components of ventilation are measured separately. The degrees of ventilation are obtained by calculation.

5 Standard conditions

5.1 Prior to measurement, the cigarettes shall be conditioned in an atmosphere as specified in ISO 3402.

5.2 Ventilation measurements shall be made on unlit cigarettes in accordance with the test atmosphere as specified in ISO 3402.

5.3 The direction of airflow in the cigarette shall be that which would occur when the cigarette is smoked.

6 Requirements for apparatus

6.1 The apparatus used shall allow separate assessment of the ventilation components shown in [Figure 1](#).

6.2 The cigarettes shall be held in the measurement head, by an encapsulation device, with an encapsulation depth as defined by ISO 3308.

6.3 Seals used to hold the cigarette and partition ventilation measurement regions shall be sized and positioned appropriately to the dimensions of the product under test to minimize any systematic influence on measured parameters. See [Figure 2](#).

6.4 The measuring pressure surrounding the cigarette contained in the measurement head, other than at the front end and the mouth end enclosed in the holding seal, shall not be more than 20 Pa lower than that of the testing atmosphere when the total airflow is applied.

NOTE Experiments conducted during the development of this method show that the measured ventilation flows reduce proportionally to increased pressure drop of the apparatus' ventilation measurement path.

6.5 A generator for total airflow shall be used to establish the measurement conditions.

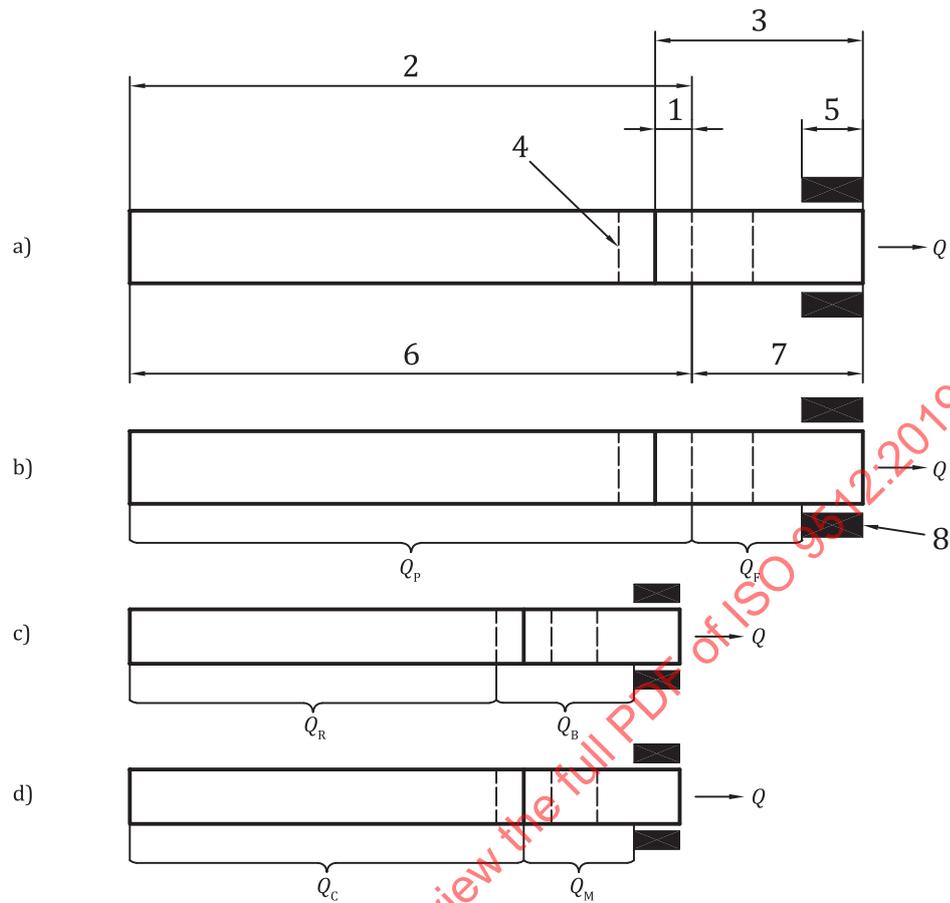
Deviations from the total airflow shall not exceed $\pm 0,10$ ml/s.

NOTE A critical flow orifice (CFO) is normally used to establish a constant total airflow for vacuum-based measurement systems.

6.6 The device used for measurement of ventilation airflows shall have no intrinsic effect on the volumetric airflow measurement.

See [Figure 2](#).

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Key

- 1 overlap
- 2 cigarette paper
- 3 tipping paper
- 4 butt mark
- 5 standard depth of encapsulation
- 6 tobacco rod
- 7 filter
- 8 encapsulation device

Total airflow rate, $Q = 17,5 \text{ ml/s}$

Degree of filter ventilation, $V_F = \frac{Q'_F}{Q} \times 100 \%$

Degree of paper ventilation, $V_P = \frac{Q'_P}{Q} \times 100 \%$

Degree of total ventilation, $V = V_F + V_P = \frac{Q'_F + Q'_P}{Q} \times 100 \%$

Degree of burnable tobacco rod ventilation, $V_R = \frac{Q'_R}{Q} \times 100 \%$

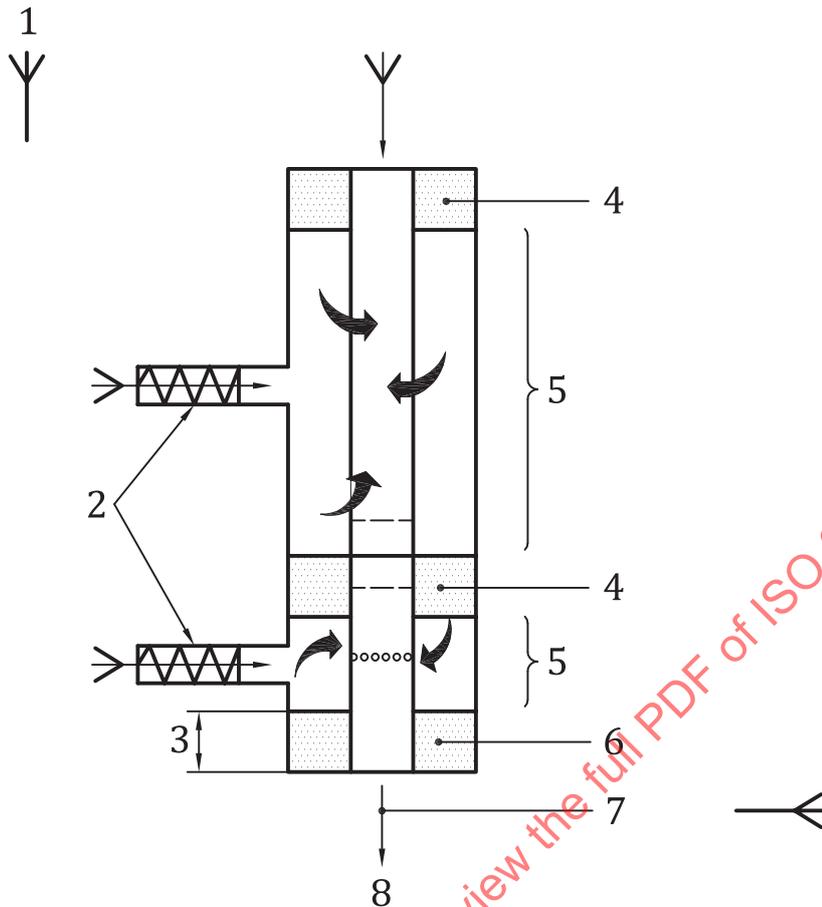
Degree of butt ventilation, $V_B = \frac{Q'_B}{Q} \times 100 \%$

Degree of cigarette paper ventilation, $V_C = \frac{Q'_C}{Q} \times 100 \%$

Degree of tipping paper ventilation, $V_M = \frac{Q'_M}{Q} \times 100 \%$

NOTE See 3.5 for the significance of the prime (') designator.

Figure 1 — Different degrees of ventilation



Key

- | | | | |
|---|--|---|---|
| 1 | test atmosphere conforming to ISO 3402 | 5 | ventilation chamber |
| 2 | ventilation flow measurement devices | 6 | fixed holding seal |
| 3 | encapsulation depth conforming to ISO 3308 | 7 | device to measure cigarette draw resistance |
| 4 | adjustable partitioning seals | 8 | total airflow |

Figure 2 – Schematic for ventilation flow measurement

7 Sampling

A sample shall be taken which is representative, on a statistical basis, of the population to be characterized.

Samples shall be free of visible defects and creases, which may impair measurement performance.

8 Checking of apparatus

The measurement device shall be calibrated in accordance with the manufacturer's recommendations, ensuring the device is leak free prior to implementing or checking calibration.

9 Procedure

9.1 Conditioning of test cigarettes

Condition the cigarette sample selected for the test as specified in 5.1.

9.2 Calibration

Calibrate the measurement device using calibration standards and calibration procedure in accordance with [Annex B](#).

Any calibration needs to span the range of values expected from the test sample required on the products to be measured.

9.3 Measurement

Ensure that the measurement apparatus has been adjusted to suit the dimensions of the cigarette to be tested.

Insert the cigarette samples to be tested into the measurement head and use the apparatus in accordance with the manufacturer's instructions.

Record the ventilation measurement parameters.

10 Expression of results

The reported value of any ventilation measurements shall be the mean value of individual measurements, expressed as a percentage of total airflow.

The results shall be expressed as follows:

- a) individual values shall be expressed to at least one decimal place;
- b) mean values shall be expressed to the first decimal place (0,05 is rounded to 0,1);
- c) the standard deviation shall be expressed to the first decimal place (0,05 is rounded to 0,1).

11 Precision

The precision of this method has been estimated by selecting three cigarette product types having nominal filter ventilation values which span the normal range of measurement for ventilated products. The results for filter ventilation are reported in Reference [2], used with permission.

Data sets from 19 laboratories that complied with the collaborative study testing protocol were used in the determination of repeatability limits, r , and reproducibility limits, R , for this method.

For each of three different ventilation levels, individual sample sets comprising 10 cigarettes were tested on five different days; a new set was tested on each day. The overall mean ventilation values are shown in [Table 1](#).

Table 1 — Filter ventilation values

Level	Mean filter ventilation value (%)
1	31,18
2	55,67
3	87,50

Outlier analysis was performed in accordance with ISO 5725-2[1] and any outliers have been removed for the determination of the mean values and r and R .

Repeatability and reproducibility statistics are given in [Table 2](#).

Table 2 — Repeatability and reproducibility statistics for cigarette filter ventilation for ventilation levels 1, 2 and 3

Ventilation level	Repeatability			Reproducibility		
	SD _R (%)	Limit (r) (%)	CoV _R (%)	SD _R (%)	Limit (R) (%)	CoV _R (%)
1	0,49	1,39	1,57	0,72	2,03	2,30
2	0,62	1,75	1,11	1,02	2,88	1,83
3	0,38	1,07	0,43	0,69	1,96	0,79

12 Test report

The test report shall show the method, instrument and instrument configuration used.

It shall also mention any operating conditions not specified in this document or regarded as optional, as well as any circumstances that might have influenced the results.

The test report shall include all details required for the complete identification of the sample and the results obtained.

It shall mention, in particular, the following information:

- product name or identification;
- date of sampling;
- date of test;
- type of instrument used, instrument configuration or settling time;
- results;
- total number of test pieces tested;
- room temperature in degrees Celsius (°C) during testing;
- relative humidity in percentage (RH %) during testing;
- atmospheric pressure.

Annex A (normative)

Calibration of ventilation standards

A.1 Calibration of ventilation standards

Ventilation standards are used to calibrate measuring instruments for the determination of the components of the total ventilation of cigarettes.

Ventilation standards have ventilation values allowing calibration of the measurement apparatus in the mid-range measurements.

A.2 Essential properties of ventilation standards

A.2.1 Ventilation standards shall be made of an inert material which is unaffected by use or ageing.

A.2.2 Standards shall closely resemble the physical size and shape of a cigarette.

A.2.3 Ventilation standards shall have defined and repeatable value of ventilation when a suction source, having a total volumetric flow rate of 17,5 ml/s is applied to the outlet of the standard.

A.2.4 The following parameters may be added:

- pressure drop with tipping ventilation zones open (ΔP_o);
- pressure drop with tipping ventilation zones closed (ΔP_c);
- pressure drop with tipping and paper ventilation zones closed (ΔP_e).

A.2.5 The airflow through the ventilation standard shall be laminar. The ventilation standard shall have repeatable measurement characteristics and shall be largely unaffected by changing atmospheric conditions.

A.2.6 Ventilation standards shall be inscribed with a unique ID having a certificate of calibration giving a traceable value of tipping ventilation. Additional parameters may be included.

The level of uncertainty of calibration of the ventilation standards shall not exceed 1,5 % absolute.

A.2.7 The certificate of calibration shall state the actual atmospheric pressure, temperature and relative humidity of the laboratory testing atmosphere during calibration.

A.3 Procedure

A.3.1 Requirements for apparatus

To determine the characteristics of the ventilation standard, it shall be held in a calibration apparatus, the mechanical arrangement of which shall not modify the characteristics of the standard nor create any systematic influences on the measurement. Measurements shall be conducted in a testing atmosphere in accordance with ISO 3402.

The calibration apparatus shall allow measurement and calibration of the pressure drop of the ventilation standard. See [Figure A.2](#).

The calibration apparatus should have a generator for a constant volumetric flow rate (Q) of $(17,5 \pm 0,3)$ ml/s at the outlet end of the ventilation standard.

NOTE 1 A critical flow orifice (CFO) is normally used to establish a constant volumetric flow rate for suction-based measurement systems.

NOTE 2 It is possible to use an alternative method of calibration to establish flow and pressure drop measurements either side of the 17,5 ml/s calibration point, which is subsequently calculated by interpolation.

A.3.2 Ventilation flow measurement

- a) The laboratory atmosphere should be maintained in accordance with ISO 3402:1999, 3.2 during conditioning and testing, as follows:
 - temperature (22 ± 2) °C
 - relative humidity (60 ± 5) %
- b) The ventilation standard should be checked for signs of damage and submitted for calibration only if in good physical condition.
- c) The ventilation standard should be cleaned if necessary.
- d) The ventilation standard should be conditioned in the laboratory atmosphere for a minimum of 12 h before measurement.
- e) The measurement apparatus should be checked to ensure that it is leak-tight according to specifications (also see [Annex D](#)) and that the seals to the ventilation standard are in good condition before the measurements commence.
- f) The performance of the measurement equipment should be validated before use by at least one reference standard with intermediate ventilation. Optionally, two further reference standards may be used to cover the whole measuring range. Alternatively, 0 % ventilation and 100 % ventilation can be checked. Measurements should not commence if the measured reference ventilation value(s) are outside the expected range.
- g) The ventilation standard should be stabilized in the measurement apparatus, with air being drawn through the standard at an airflow rate of nominally 17,5 ml/s, for a minimum of 5 minutes before measurements commence.
- h) If the volumetric flow of air entering into the ventilation path is measured using an in-line flow measurement device, this should introduce a series pressure drop of less than 20 Pa. For a higher pressure drop, it is necessary to balance the pressure between the inlets to the standard in the ventilation chamber and the front area of the standard to avoid a systematic influence on the ventilation flow.
- i) A volumetric airflow measurement device, that does not generate any systematic influence on airflow measurement, shall be used to check the total airflow that is applied to the outlet of the ventilation standard when inserted into the calibration apparatus.

NOTE It has been customary practice in the past to measure volumetric airflows by means of a soap bubble flow meter. This creates measurement errors in pressure drop calibration due to the saturation of the measurement air by the soap bubble flow meter, which causes the volumetric flow to artificially increase and the viscosity to decrease.

- j) A typical calibration procedure might comprise the following steps, although details will vary according to the apparatus used and the operating procedure for the equipment.

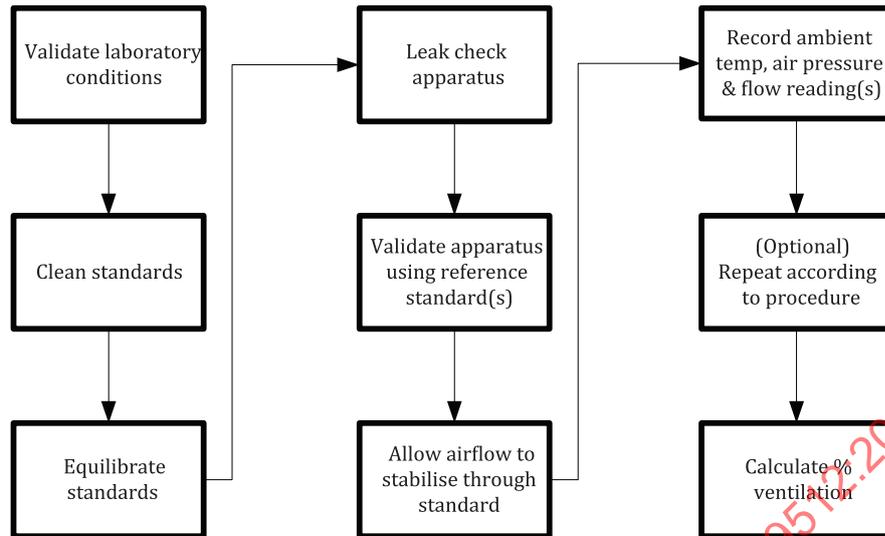


Figure A.1 — Example of a typical calibration procedure

A.3.3 Pressure drop measurement

The pressure drop characteristics of the ventilation standard shall be measured in accordance with ISO 6565.

A.3.4 Pressure drop compensation for ventilation flow measurement

The ventilation flow is expressed relative to the pressure at the outlet of the ventilation standard, created by the pressure drop of the ventilation standard when contained in a calibration apparatus.

The measured values for ventilation flows Q_i of the individual ventilation zones $i = 1, 2, \dots$ of the ventilation standard shall be modified as shown in [Formula \(A.1\)](#) to provide comparison with the 100 % total flow value as measure at the exit of the ventilation standard.

$$Q'_i = Q_i \times \frac{P_{atm}}{P_{atm} - \Delta P_z} \quad (A.1)$$

where

P_{atm} is the actual atmospheric pressure, expressed in pascals; if the atmospheric pressure is not measured, it can be approximated to the normal value of 101 325 Pa;

ΔP_z is the pressure drop of the ventilation standard with the ventilation zones open, expressed in pascals;

Q_i is the measured ventilation flow at ventilation zone i , expressed in millilitres per second;

Q'_i is the corrected ventilation flow at ventilation zone i , expressed in millilitres per second.

A.3.5 Calculation of the degree of ventilation

The degree of ventilation for the individual ventilation zones, V_i , is expressed as [Formula \(A.2\)](#):

$$V_i = \frac{Q'_i}{Q} \times 100 \% \tag{A.2}$$

where

Q is the total airflow rate, expressed in millilitres per second;

Q'_i is the corrected volumetric flow at ventilation zone i , expressed in millilitres per second;

V_i is the degree of ventilation at ventilation zone i , expressed as a percentage.

with the subscript i representing the specific ventilation zone; F, P, R, B, C or M (see [Figure 1](#) and [Figure A.2](#)).

A.3.6 Precision

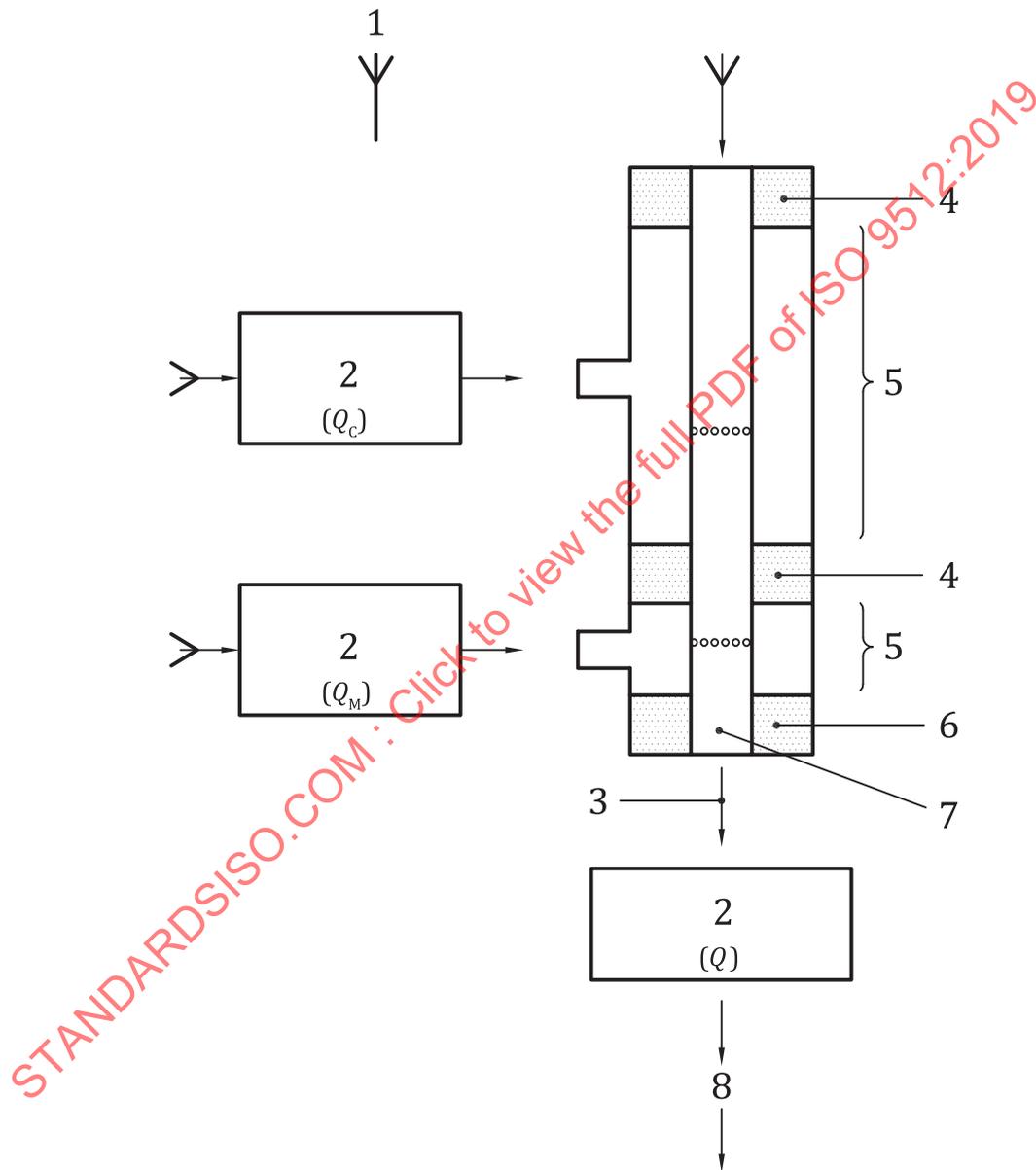
Under the auspices of the CORESTA Physical Test Methods Sub-Group, an interlaboratory study involving all four laboratories able to carry out the required procedure, calibration standards for filter ventilation were circulated between the laboratories and each calibration standard was measured three times under repeatability conditions on two separate days. From the data, the mean value, repeatability standard deviation and reproducibility standard deviation were calculated for individual determinations over both days following ISO 5725-2[1]. The results for ventilation standards are reported in Reference [3], used with permission. [Table A.1](#) presents repeatability and reproducibility as % ventilation and [Table A.2](#) presents the coefficient of variation of repeatability and reproducibility. Since there were only four participating laboratories, r and R limits are not presented.

Table A.1 – Mean value, repeatability standard deviation and reproducibility standard deviation of the degree of filter ventilation

Degree of filter ventilation (%)			
Standard	Global mean	Repeatability standard deviation	Reproducibility standard deviation
Nominal 20 %	18,62	0,08	0,11
Nominal 50 %	51,00	0,13	0,39
Nominal 80 %	78,10	0,11	0,54

Table A.2 — Repeatability and reproducibility coefficient of variation of the degree of filter ventilation

CoV of filter ventilation (relative %)		
Standard	Repeatability CoV	Reproducibility CoV
Nominal 20 %	0,43	0,57
Nominal 50 %	0,25	0,76
Nominal 80 %	0,15	0,69



Key

- | | | | |
|---|------------------------------------|---|------------------------------------|
| 1 | atmosphere conforming to ISO 3402 | 5 | ventilation chamber |
| 2 | volumetric flow measurement device | 6 | fixed holding seal |
| 3 | pressure drop (ΔP_Z) | 7 | outlet end of ventilation standard |
| 4 | partitioning seal | 8 | total flow of drawn air |

Figure A.2 — Calibration apparatus

Annex B (normative)

Calibration of ventilation measurement instruments using ventilation and pressure drop standards

B.1 Calibration of instruments

The calibration and performance testing of instruments for measuring the ventilation of cigarettes shall be conducted in accordance with the manufacturer's instructions.

B.2 Principle

For the best accuracy of interpolated measurements, the instrument is calibrated as closely as possible to full scale or at the extreme end of the measurement range of products to be tested.

The instrument's measurement system is tested to ensure that a valid zero ventilation measurement can be established. The measurement system is then checked for leakage and linearity using at least one ventilation standard having an intermediate value.

B.3 Method

B.3.1 The instrument's measurement system should be checked for leaks, in accordance with the manufacturer's instructions, before undertaking calibration.

NOTE An example of leak testing is given in [Annex D](#).

B.3.2 The ventilation standard should be inserted into the measuring head, in accordance with the manufacturer's instructions, and allowed to equilibrate to the temperature of the measuring air. When the instrument reading is stable, calibration should be completed.

B.3.3 The linearity of the established calibration should be checked. At least one intermediate value ventilation standard should be used to check a mid-range value.

B.3.4 Ventilation measurement instruments with the additional capabilities to measure draw resistance of cigarettes and apply draw resistance compensation to the ventilation measurements shall have their pressure drop measurement systems calibrated in line with ISO 6565.

NOTE If only the ventilation value is measured and the equipment does not compensate the effect of pressure drop, then this value can be corrected to the compensated value according to the method given in informative [Annex C](#).

B.3.5 A preferred method of calibrating cigarette ventilation and pressure drop measuring instruments is to use multiple parameter calibration standards that have certificated traceable values for the following parameters:

- tipping ventilation;
- paper ventilation;
- pressure drop with tipping ventilation zones open (ΔP_0);

- pressure drop with tipping ventilation zones closed (ΔP_c);
- pressure drop with tipping and paper ventilation zones closed (ΔP_e).

B.3.6 The use of a single standard reduces the number of calibration pieces required, reduces the risk of operator error and effects due to handling, and reduces the time taken to accomplish a calibration sequence.

The three-stage pressure drop calibration and calibration check which can be achieved with measurements ΔP_e , ΔP_c and ΔP_o , respectively, also provides a valid leakage and linearity check.

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Annex C (informative)

Measurement of ventilation airflows of cigarettes

C.1 Theoretical considerations

The degree of ventilation is determined by measuring the volumetric airflow entering defined regions of the cigarette.

These measurements are made on the atmosphere side of the cigarette and are then compared with the total flow exiting the cigarette at a reduced pressure, i.e. atmospheric pressure less the “draw resistance” value of the cigarette.

The measurement of volumetric flow, in a pneumatic circuit, is dependent upon the air density at the point of measurement.

To compare volumetric flows, the measurements should be standardized to the same atmospheric conditions.

C.2 Generation of measurement errors — Need to compensate for draw resistance

Consider the measurement of the ventilation airflow of a cigarette having a zero pressure drop between its ventilation holes and outlet end.

The measured volumetric flow into the ventilation region would be the same as if it were measured at the outlet end. This is due to the artificial situation of the cigarette not having a pressure drop; i.e. the volumetric airflows would not be modified by different gas densities. If the cigarette had a draw resistance of 981 Pa (100 mmWG), the gas pressure at the outlet end would be 981 Pa (100 mmWG) below the one existing in the ventilation region of the cigarette.

Since the volumetric exit flow (Q) is constant at 17,5 ml/s regardless of the sample draw resistance, the respective volumetric flow measurements can be compared if the effect of draw resistance on the ventilation flow is quantified.

Boyle’s Law is used to determine the actual ventilation volumetric flow as measured at the input of the tipping region, as shown in [Formula \(C.1\)](#):

$$Q_1 \times P_1 = Q_2 \times P_2 \quad (C.1)$$

where

Q_1 is the volumetric flow into the tipping ventilation region, in millilitres per second;

P_1 is the atmospheric pressure at the input of the filter region, in pascals;

Q_2 is the total airflow in millilitres per second (=17,5);

P_2 is the pressure at the outlet end (i.e. P_1 minus the draw resistance), in pascals.

If P_1 is the normal atmospheric pressure (i.e. 101 325 Pa), then for a draw resistance of 100 mmWG the value of P_2 will be as follows [see [Formula \(C.2\)](#)]:

$$P_1 - (100 \times 9,806\ 7) = 100\ 344\ \text{Pa} \quad (\text{C.2})$$

and hence [see [Formula \(C.3\)](#)]:

$$Q_1 = \frac{Q_2 \times P_2}{P_1} = \frac{17,5 \times 100\ 344}{101\ 325} = 17,33\ \text{ml/s} \quad (\text{C.3})$$

NOTE In this method, the values given previously in mmWG are converted into pascals (Pa) using the following correction factor:

$$1\ \text{mmWG} = 9,806\ 7\ \text{Pa}$$

This shows that the ventilation airflow of a cigarette having a draw resistance of 981 Pa (100 mmWG) is reduced and would measure 0,97 % lower when compared to the constant exit flow of 17,5 ml/s from the mouth end.

Measuring cigarettes having a draw resistance in the region of 981 Pa to 2 452 Pa (100 mmWG to 250 mmWG) will result in an error of 1 % to 2,5 % absolute if the ventilation flow is not compensated for the draw resistance value of the cigarettes.

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Annex D (informative)

Determination of the leakage of the ventilation measurement system

D.1 General

This principle of leakage testing can be applied to the range of ventilation measurement instruments used within the industry and is given as an example.

For system-specific techniques and recommended test and inspection regimes, reference should be made to the manufacturer's instructions.

D.2 Principle

D.2.1 Leakage testing is carried out to identify defective adjustable seals and to check the sealing integrity of ventilation (measurement) chambers. The usual sources of leaks can normally be detected by the use of intermediate ventilation and pressure drop calibration standards to check the accuracy of mid-range measurements following a full-scale calibration.

Normally a 100 % standard, made from a non-permeable material, is used to calibrate the full-scale limit of the paper and filter ventilation measurement systems. The measurement system can also be tested for a valid zero % ventilation measurement by initiating a ventilation measurement on a non-ventilated and non-permeable rod-shaped test piece.

D.2.2 Other leaks can be encountered which may not be evident when testing and/or calibrating with a 100 % standard. This is due to the fact that the standard is impervious to airflow leakage with the exception of the purposely manufactured ventilation region(s).

D.2.3 Ventilation measurement systems that include measurement of cigarette draw resistance with filter ventilation zone open (ΔP_o) and closed (ΔP_c) use electrovalves to isolate the ventilation measurement regions from the atmosphere and the ventilation airflow measurement devices.

With these systems, it is possible to incur leaks that are not evident when conducting a 100 % calibration or checking with an intermediate standard but which invalidate measurements performed upon cigarettes. This is discussed in the following clauses of this annex.

D.3 Example of a method

D.3.1 A 100 % ventilation standard is used, in the normal manner, to calibrate the full-scale limit of the paper and filter ventilation measurement systems. This ensures that during the time of calibration the total airflow (Q) is directed from the atmosphere through the chosen ventilation chamber to exit at the outlet end of the ventilation standard.

D.3.2 Directly following calibration, any ventilation measurement chambers that can be isolated from the atmosphere to achieve pressure drop measurement or any other associated measurement, should be tested for leakage.