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Cigarettes — Routine analytical cigarette smoking machine — Definitions and standard conditions with an intense smoking regime

Cigarettes — Machine à fumer analytique de routine pour cigarettes — Définitions et conditions normalisées avec un régime de fumage intense

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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).

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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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 126, *Tobacco and tobacco products.*

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

Historically, a set of ISO standards have been developed to specify the requirements of analytical cigarette smoking machines and their use for the quantitative determination of a number of cigarette smoke constituents [such as total particulate matter, nicotine free dry particulate matter, water, nicotine or benzo[a]pyrene] with a unique standard smoking regime. The description of this smoking regime is provided in ISO 3308.

Later, requirements to provide smoke constituents data with an intense smoking regime, different from the ISO 3308 smoking regime, originated from different countries and the Conferences of the Parties to the Framework Convention on Tobacco Control, resulting in a need to specify the conditions for the use of the intense smoking regime on analytical cigarette-smoking machines.

This document is the result of the work performed by ISO/TC 126, comprising experts from members and liaison organizations, including WHO. Elaboration of this document took into account practical work conducted in the framework of a collaborative study involving 35 laboratories (published as Technical Report ISO/TR 19478-1 and ISO/TR 19478-2). It provides specifications for analytical cigarette smoking machines to be used with an intense smoking regime.

No machine smoking regime can represent all human smoking behaviour:

— it is recommended that cigarettes also be tested under conditions of a different intensity of machine smoking than those specified in this document;

— machine smoking testing is useful to characterize cigarette emissions for design and regulatory purposes, but communication of machine measurements to smokers can result in misunderstandings about exposure and risk across brands;

— smoke emission data from machine measurements may be used as inputs for product hazard assessment, but they are not intended to be nor are they valid as measures of human exposure or risks. Communicating differences between products in machine measurements as differences in exposure or risk is a misuse of testing using ISO standards.

Cigarettes — Routine analytical cigarette smoking machine — Definitions and standard conditions with an intense smoking regime

1 Scope

This document:

— defines smoking parameters and specifies the conditions to be provided for the routine analytical machine smoking of cigarettes under specified intense conditions;

— specifies the requirements for a routine analytical smoking machine conforming with these conditions;

— specifies additional test methods for machine verification.

Annex A gives examples of designs of smoking machine enclosures.

NOTE The type of analytical smoking machine used could impact the mass of total particulate matter collected on the smoke trap. This might be due to either incomplete collection or evaporation of water and other volatile compounds from the smoke trap.

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

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

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
test atmosphere
atmosphere to which a sample or test piece is exposed throughout the test

Note 1 to entry: It is characterized by the following parameters: temperature, relative humidity and pressure.

[SOURCE: ISO 3308:2012, 3.1, modified — Note 2 to entry has been deleted.]

3.2
butt length
length of unburnt cigarette remaining at the moment when the smoking is stopped

[SOURCE: ISO 3308:2012, 3.2]

3.3
restricted smoking
condition that exists when the butt end of a cigarette is closed to the atmosphere between successive puffs

[SOURCE: ISO 3308:2012, 3.3]

3.4
pressure drop
static pressure difference between the two ends of a pneumatic circuit (of a smoking machine) when it is traversed by an air flow under steady conditions in which the measured volumetric flow, under standard conditions, at the output end is 17,5 ml/s

[SOURCE: ISO 7210:2018, 3.1, modified — Notes to entry have been added.]

Note 1 to entry: The pressure drop of a circuit or device is dependent on the viscosity, density and flow rate of the gas flowing through it. For the comparison of different devices, circuits or products, a reference point is defined using ambient air under the conditions described above. This reference point is established in many ISO standards, instruments and laboratories.

Note 2 to entry: The relationship between the determined values of pressure drop of different devices, circuits or products measured at the reference condition stays the same under changed conditions as long as the area of linearity is kept. Therefore, no reason is given to change the reference point if the devices, circuits or products are used under other conditions, such as flow rate. For example, a pressure drop device of 1 kPa at 17,5 ml/s will result in a measured pressure drop at 27,5 ml/s of around 1,6 kPa (1*27,5/17,5) if the ambient conditions are stable.

3.5
pressure drop device
device of known pressure drop determined under reference conditions as defined in 3.4 integrated into a pneumatic circuit

3.6
puff duration
interval of time during which the port of a smoking machine is connected to the suction mechanism

[SOURCE: ISO 3308:2012, 3.7, modified]

3.7
puff volume
volume leaving the butt end of a cigarette and passing through the smoke trap of a smoking machine

[SOURCE: ISO 3308:2012, 3.8, modified]

3.8
puff number
number of puffs necessary to smoke a cigarette to a specified butt length

[SOURCE: ISO 3308:2012, 3.9]

3.9
puff frequency
number of puffs in a given time

[SOURCE: ISO 3308:2012, 3.10]

3.10
puff termination
termination of the connection of the port to the suction mechanism

[SOURCE: ISO 3308:2012, 3.11]

3.11
puff profile
flow rate measured directly behind the butt end of the cigarette, and depicted graphically as a function of time

[SOURCE: ISO 3308:2012, 3.12]

3.12
dead volume
volume which exists between two defined points of a pneumatic circuit

[SOURCE: ISO 3308:2012, 3.13, modified]

3.13
cigarette holder
device for holding the butt end of a cigarette during smoking

[SOURCE: ISO 3308:2012, 3.14, modified — 'mouth end' replaced with 'butt end'.]

3.14
smoke trap
device for collecting such part of the smoke from a sample of cigarettes as is necessary for the determination of specified smoke components

[SOURCE: ISO 3308:2012, 3.15]

3.15
port
aperture of the suction mechanism through which a puff is drawn and to which is attached a smoke trap

[SOURCE: ISO 3308:2012, 3.16]

3.16
channel
element of a smoking machine consisting of one or more cigarette holders, one trap and a means of drawing a puff through the trap

[SOURCE: ISO 3308:2012, 3.17]

3.17
compensation
ability to maintain constant puff volumes and puff profiles when the pressure drop at the port changes

[SOURCE: ISO 3308:2012, 3.18]

3.18
cigarette position
position of a cigarette on the smoking machine

Note 1 to entry: In particular, it is determined by the angle made by the longitudinal axis of the cigarette and the horizontal plane when a cigarette is inserted into a cigarette holder in an analytical smoking machine.

[SOURCE: ISO 3308:2012, 3.19]

3.19
mainstream smoke
smoke which leaves the butt end of a cigarette during the smoking process

[SOURCE: ISO 3308:2012, 3.20]

3.20
sidestream smoke
smoke which leaves a cigarette during the smoking process other than from the butt end

[SOURCE: ISO 3308:2012, 3.21]

3.21
ashtray
device positioned under the cigarettes in their holders to collect ash falling from the cigarettes during smoking

[SOURCE: ISO 3308:2012, 3.22]

3.22
clearing puff
any puff taken after the cigarette has been extinguished or removed from the cigarette holder

[SOURCE: ISO 3308:2012, 3.23]

3.23
ambient air flow
air flow around the cigarettes during the smoking process

Note 1 to entry: See Clause 6 and Annex A.

[SOURCE: ISO 3308:2012, 3.24]

4 Standard conditions

4.1 Puff duration

The standard puff duration shall be (2,00 ± 0,02) s.

4.2 Puff volume

The standard puff volume V, with $V = V_1 + V_2$, measured in series with a pressure drop device of 1 000 Pa ± 50 Pa shall be (55,0 ± 0,6) ml. In one puff duration not less than 95 % of the puff volume shall leave the butt end of the cigarette (V_1).

4.3 Puff frequency

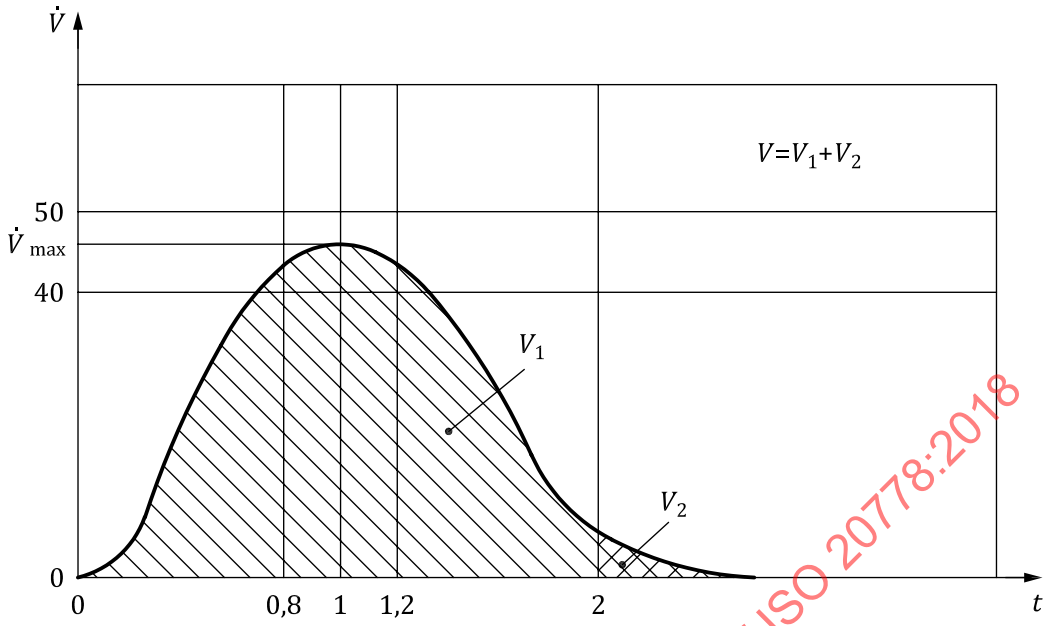
The standard puff frequency shall be one puff every (30 ± 0,5) s.

4.4 Puff profile

The puff profile shall be measured with an impedance of 1 000 Pa ± 50 Pa as specified in 3.4. It shall be shaped as shown in Figure 1 (known as bell-shape profile) with a maximum between 0,8 s and 1,2 s from the start of the puff. The increasing and decreasing parts of the profile shall not have more than one point of inflection each. The maximum flow rate shall be between 40 ml/s and 50 ml/s. At no point shall the direction of flow be reversed.

NOTE 1 The drives for piston pumps result in small perturbations in flow which are acceptable.

NOTE 2 The determination of the puff profile is described in ISO 7210.



Key

$\dot{V}$ volumetric flow, ml/s

t time, s

Figure 1 — Puff profile (idealized)

4.5 Restricted smoking

The design of the smoking machine shall fulfil the conditions for restricted smoking and shall be certified by the manufacturer.

The verification of restricted smoking is described in ISO 7210.

4.6 Puff number

Each individual puff shall be counted and recorded and the puff number rounded off to the nearest one-tenth of a puff, based on the puff duration.

4.7 Cigarette holder

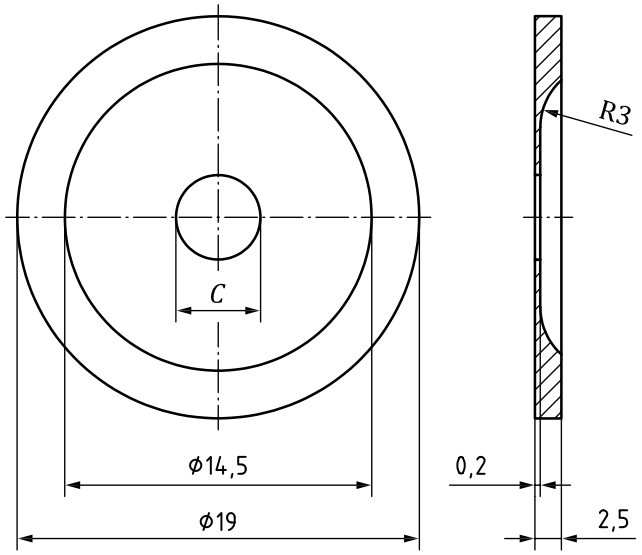
The design of the standard cigarette holder is such that it shall cover 9,0 mm, with a range of 8,0 mm to 9,5 mm, from the butt end of a cigarette, and shall be impermeable to smoke components and to air. Labyrinth seals with dimensions appropriate for the diameter of the cigarettes under test shall be used in the cigarette holder (see Figure 2 a). Four labyrinth seals shall be used; the one closest to the butt end (back seal) shall be reversed.

The butt end of the cigarette shall be partly obstructed by a perforated disc (washer) of plain synthetic rubber. The dimensions of the labyrinth seals and the washer are given in Figure 2. The support of the washer could be either part of the cigarette holder or integrated to the front end of the smoke trap. An example of a suitable assembly is given in Figure 3.

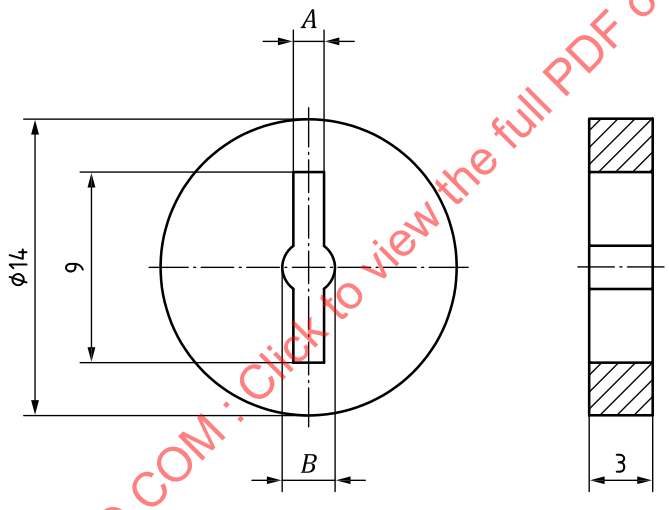
The axis of the holder shall be within 0° to + 5° of the horizontal and the holder shall ensure that the cigarette is held within ±5° of the holder axis.

NOTE Manufacturing tolerances for the individual components of the cigarette holder might result in an uneven tolerance about the specified 9 mm insertion depth.

Dimensions in millimetres, tolerance for all dimensions is ±0,1 mm



a) Labyrinth seal

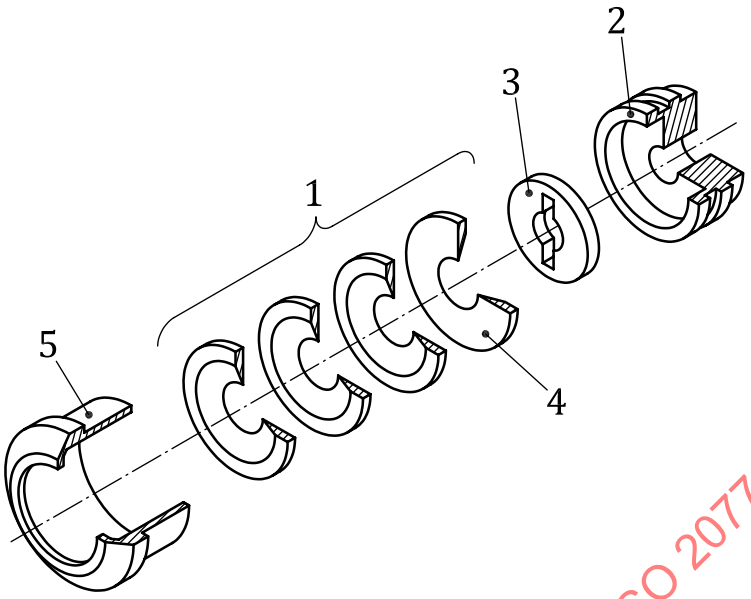


b) Washer

Diameter	Cigarette		
	A[a]	B[a]	C[a]
4,5 to 5,49	1,45	2,5	4
5,5 to 6,49	1,7	3	4,5
6,5 to 7,49	1,95	3,5	5,5
7,5 to 9	2,2	4	6,5

[a] Manufacturing tolerances are ±0,4 mm (standard tolerances for rubber).

Figure 2 — Cigarette holder: labyrinth seal and perforated disc (washer)



Key

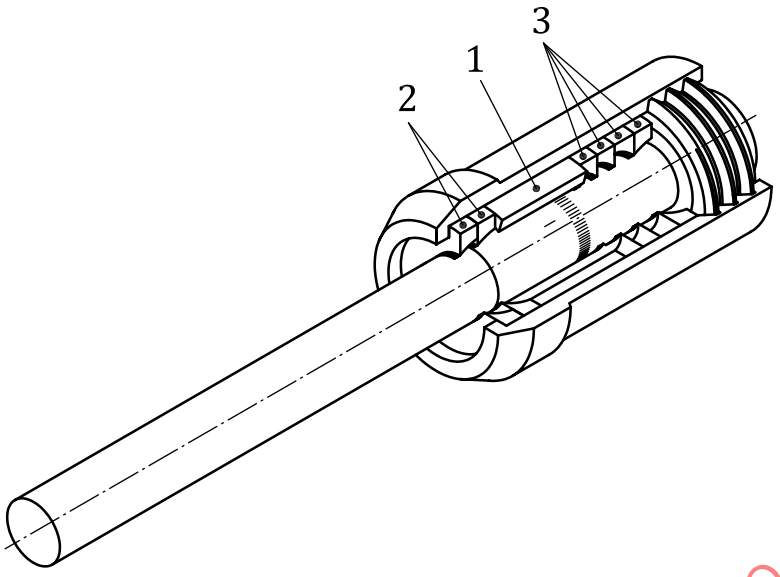
1 labyrinth seals
2 washer support
3 washer
4 labyrinth seal (reversed)
5 labyrinth cap

NOTE Washer support could be an integral part of the central glass fibre smoke trap.

Figure 3 — Cigarette holder (schematic)

If required, it is possible to seal the ventilation zone of a cigarette by a modification to the cigarette holder as illustrated in Figure 4. The modification contains a spacer (1) and additional labyrinth seals (2) positioned in front of the four labyrinth seals (3) of the standard holder. The dimension of the spacer shall be selected in a way that the ventilation zone of the cigarette is fully encapsulated within the labyrinth seals. An example of a suitable assembly is given in Figure 4.

NOTE The total insertion depth is extended by the spacer and the additional labyrinth seals.



Key

1 spacer
2 additional labyrinth seals
3 labyrinth seals (standard configuration)

Figure 4 — Example of a cigarette holder with cavity to seal the ventilation zone (schematic)

4.8 Cigarette position

The cigarette holders shall be arranged so that no cigarette influences the burning of any other cigarette.

The cigarette shall be positioned in the holder so that the butt end is in contact with the washer or equivalent end stop when inserted.

4.9 Ashtray position

The ashtray shall be placed in a horizontal plane between 20 mm and 60 mm below the plane of the axes of the cigarettes.

5 Specification for the routine analytical smoking machine

5.1 General

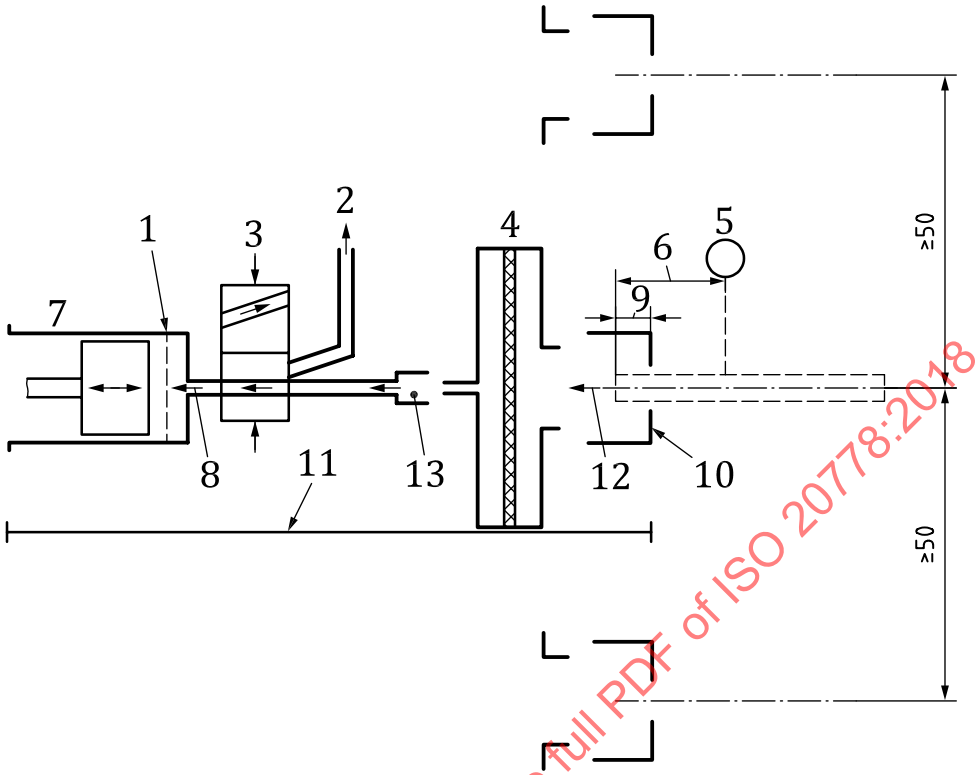
The smoking machine shall conform with the specified conditions (see 4.1 to 4.9) and the special conditions given in 5.2 to 5.8.

5.2 Operating principle and puff profile

5.2.1 The machine shall include a device to draw a fixed volume of air (puff) through a cigarette. A schematic diagram is shown in Figure 5.

5.2.2 The machine shall produce a puff profile as defined in 4.4.

Dimensions in millimetres



Key

1	piston top dead centre	8	swept volume
2	gas phase out	9	insertion depth
3	control valve	10	cigarette holder
4	smoke trap	11	channel
5	puff termination device	12	puff volume
6	butt length	13	port
7	piston pump		

Figure 5 — Smoking machine (schematics)

5.2.3 The machine shall be a restricted smoker (i.e. fulfil the conditions for restricted smoking).

5.3 Reliability and compensation

5.3.1 The machine shall contain devices to control the puff volume, the puff duration and the puff frequency.

5.3.2 The machine shall possess the mechanical and electrical reliability necessary to meet the standard conditions regarding these parameters (see 4.1 to 4.4) during the test for prolonged periods.

5.3.3 The machine shall be capable of sufficient compensation.

When the machine has initially been set to give a puff volume of 55 ml without a pressure drop device, a reduction of no more than 2,5 ml shall be observed when the machine is tested with a pressure drop device of 2 kPa.

5.3.4 The smoking machine design shall result in the resistance to flow of the connecting piping between the butt of the cigarette and the suction mechanism fulfilling the requirements given in 4.4.

5.3.5 The smoking machine design shall result in the total dead volume between the butt of the cigarette and the suction mechanism fulfilling the requirements defined in 4.4.

5.4 Cigarette holders and smoke traps

5.4.1 The machine shall contain devices for holding the cigarette and for trapping the smoke produced.

5.4.2 The cigarette holders shall be capable of holding the butt end of the cigarette during smoking. Labyrinth seals shall be used for attaching cigarettes.

5.4.3 Devices shall be provided for attaching cigarette holders to the machine so that the cigarette holders are held rigidly.

A screwed fitting or "O" ring seal is recommended. Rubber tubing is considered to be unsatisfactory.

5.4.4 The cigarettes to be smoked shall be attached to the ports or the smoke traps by cigarette holders (see 4.7).

5.4.5 The machine shall be designed to hold the cigarettes in the standard position (see 4.8).

The system shall be designed to prevent losses of smoke components between the butt end of the cigarette and the smoke trap.

5.4.6 The cigarette holders shall be arranged so that the sidestream smoke does not affect cigarettes smoked in adjacent holders (see 4.8). The distance between the centres of adjacent burning zones shall be at least 50 mm.

5.4.7 When the smoking machine is used for collecting particulate matter, it shall be fitted with a glass fibre filter smoke trap, comprising the following.

a) Airtight filter holder and end caps made of a non-hygroscopic and chemically inert material, able to contain a filter pad of glass fibre material 1 mm to 2 mm thick. The rough filter surface shall face the oncoming smoke. Two examples are given in Figure 6.

   Different designs of smoke trap can meet this requirement. It is recommended that for smoking machines where three cigarettes are smoked per trap, the diameter of the glass fibre filter pad should be 44 mm. For machines where 10 cigarettes are smoked per trap, the diameter of the glass fibre filter pad should be 92 mm.

b) Filter material which shall retain at least 99,9 % of all particles with a diameter equal to or greater than 0,3 µm of a dioctyl phthalate aerosol at a linear air velocity of 140 mm/s. The pressure drop of the filter assembly shall not exceed 900 Pa at this air velocity. The content of binder shall not exceed 5 % as mass fraction. Polyacrylate and polyvinyl alcohol (PVA) have been found to be suitable binders for this material.

The filter assembly shall be capable of quantitatively retaining all of the particulate matter in the mainstream smoke produced by the cigarette without loss. In addition, the filter assembly shall be chosen so that the increase in pressure drop of the assembly does not exceed 250 Pa when measured after the smoking run.

5.4.8 Each channel shall have a puff-termination device linked to a butt length (mark) sensor and puff counter. When activated by the sensor, the device shall prevent any further drawing of air through the cigarette.

NOTE There are different technologies available fulfilling the above requirements. At the time of publication of this document the used technologies are:

a) micro-switch activated by the burning through of a 100 % cotton, (48 ± 4) tex thread, placed on the butt mark;

b) a specially shielded infrared detector. The shielding defines a detection border plane perpendicular to the cigarette. The crossing of that plane by the burning cone terminates the puff;

c) optical image processing systems using a camera;

d) thermocouple systems designed as thermo-probes or thermo-loops.

5.4.9 The machine shall be capable of smoking a wide range of cigarettes of different lengths, diameters and cross-sectional shapes while conforming with the standard conditions regarding cigarette butt lengths.

5.4.10 The machine shall be capable of making one or more clearing puffs after the termination of smoking.

5.5 Test atmosphere

The test atmosphere shall be controlled to ensure that all the cigarettes are smoked under identical conditions with regard to ambient air flow.

The temperature and relative humidity of the test atmosphere shall correspond to those specified in ISO 3402:

— temperature: (22 ± 2) °C;

— relative humidity: (60 ± 5) %.

The design of the enclosure around the smoking machine and of the sidestream smoke extraction system should provide identical conditions with regard to air flow around the cigarettes for the different designs of smoking machine which conform to the specification in this document (see Clause 6 and Annex A).

5.6 Puff counting

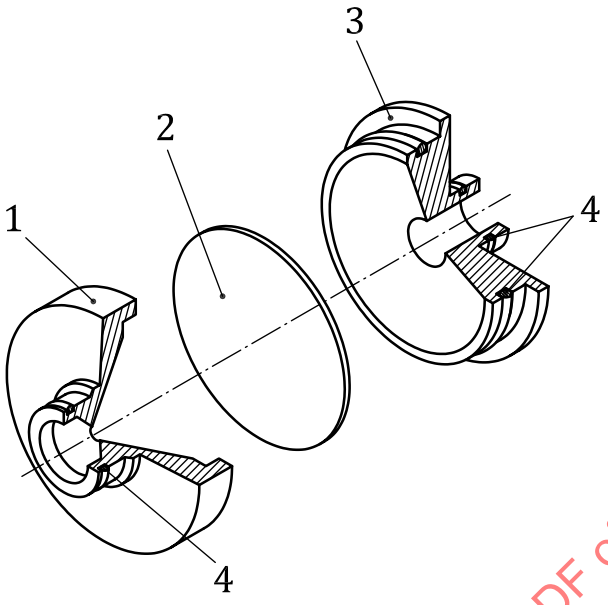
Each port shall have its own puff counter capable of counting to the nearest 0,1 puff (see 4.6).

5.7 Ignition

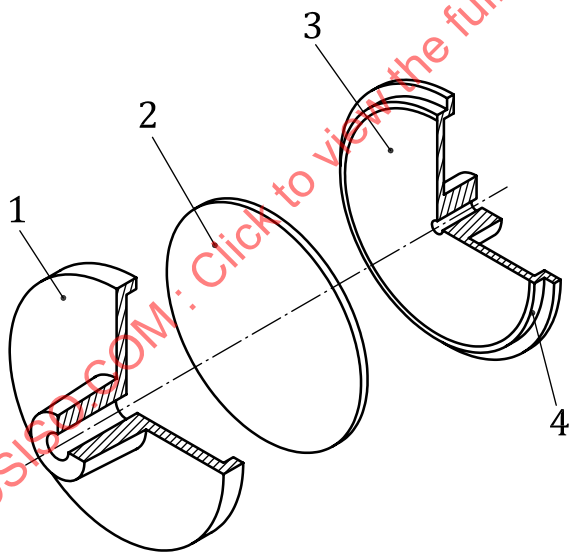
Flameless ignition shall be used. The lighters shall light the cigarettes at the first attempt without either touching or pre-charring the cigarette.

5.8 Smoking enclosure

The smoking process shall be carried out in an enclosure (see Annex A), preferably transparent, which may be an integral part of the smoking machine, or a housing in which the machine can be sited. The enclosure shall be capable of being fitted with an air-extraction device to facilitate the controlled removal of sidestream smoke from the enclosure.



a)



b)

Key

1 GF holder front
2 filter pad
3 GF holder back
4 "O"-ring seal(s)

Figure 6 — Examples of glass fibre filter (GF) smoke traps (schematic)

6 Control and monitoring of ambient air flow around cigarettes

6.1 General

This clause specifies:

— the ambient air velocities surrounding cigarettes in an analytical smoking machine during the smoking process;

— the methods of air velocity measurement and the location where air velocity shall be measured.

There are two principal designs for smoking machines which satisfy the conditions specified in this document:

— type a) in which the position of the cigarette in its holder is fixed, i.e. adjustments are made by moving the puff termination device;

— type b) in which the position of the puff termination device is fixed, i.e. adjustments are made by moving the cigarette and its holder.

Examples of such machines are shown in Annex A.

6.2 Air velocity measurement locations

6.2.1 General

The reference points at which the measurement of air velocity has to be made shall be given. The required measurements shall be made such that the centre of the air velocity meter probe is within 2 mm in each plane of the specified position.

6.2.2 Smoking machines, type a)

The air velocity shall be measured, with the cigarette holders in place, at a point on the axis of the cigarette, 74 mm from the butt end of the cigarette.

6.2.3 Smoking machines, type b)

The air velocity shall be measured with the cigarette holders in place at a point on the axis of the cigarette as held in its holder 40 mm towards the end of the cigarette which is to be lit, measured from the position of the puff termination device.

In order to check the uniformity of air flow across the smoking machine, measurements shall be made at a central port and at a port near each extreme. Additional measurements may be required upon installation or relocation of the machine.

NOTE Certain types of air velocity probe are mounted directly in a port, thereby replacing a filter and cigarette holder during measurement.

6.3 Specification of the air velocity meter

An air velocity meter capable of accuracy of not less than 20 mm/s at 200 mm/s air velocity shall be used. The air velocity measuring equipment shall be capable of integrating air velocity data over a minimum period of 10 s.

The value of a measurement of air velocity shall consist of the average of not less than 10 replications of 10 s integrations.

NOTE Advice on appropriate meters can be obtained from the suppliers of smoking machines.

6.4 Standard value of air velocity

The standard value of the air velocity shall be 200 mm/s.

Laboratory procedures should aim to ensure that the air velocity average during a smoking run lies in the range of 170 mm/s to 230 mm/s.

For smoking machines type b), the air velocity measured at an individual port should be within the range of 150 mm/s to 250 mm/s.

6.5 Setting and checking air velocity

Air velocity should be checked, and adjusted if necessary, when the machine is used.

Extreme atmospheric conditions, external to the test atmosphere, may affect air flow in smoking machine enclosures. In such circumstances, more frequent checks of air velocity should be made.