BS ISO 3308:2012

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Routine analytical cigarette-smoking machine — Definitions and standard conditions

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National foreword

This British Standard is the UK implementation of ISO 3308:2012. It supersedes BS ISO 3308:2000+A1:2009 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AW/40, Tobacco and tobacco products.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

ISO 3308

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Routine analytical cigarette-smoking machine — Definitions and standard conditions

Machine à fumer analytique de routine pour cigarettes — Définitions et conditions normalisées

Reference number
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Foreword

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

ISO 3308 was prepared by Technical Committee ISO/TC 126, *Tobacco and tobacco products*.

This fifth edition cancels and replaces the fourth edition (ISO 3308:2000), which has been technically revised. Subclause 5.8, the last formula in Annex C and the figures have been editorially revised. It also incorporates the amendment ISO 3308:2000/Amd.1 2009.

Introduction

Experience and knowledge gained from the use of analytical cigarette-smoking machines has highlighted a need to specify certain requirements, which are addressed in this International Standard.

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 International Standard;

— 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 differences in 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.

INTERNATIONAL STANDARD ISO 3308:2012(E)

Routine analytical cigarette-smoking machine — Definitions and standard conditions

1 Scope

This International Standard:

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

— specifies the requirements for a routine analytical smoking machine complying with the standard conditions.

Annex A specifies the ambient air velocities surrounding cigarettes in a routine analytical smoking machine, the mechanical design of the enclosures immediately surrounding them, and the methods of air velocity measurement including the location where air velocity is measured.

Annex B describes, as an example, the special characteristics of a typical smoking machine incorporating a piston type of puffing mechanism.

Annex C includes a diagram of a puff profile and illustrates definitions and standard conditions.

2 Normative references

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

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

3 Terms and definitions

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

3.1
test atmosphere
atmosphere to which a sample or test piece is exposed throughout the test

NOTE 1 It is characterized by specified values for one or more of the following parameters: temperature, relative humidity and pressure, which are kept within the specified tolerances.

NOTE 2 The test may be carried out either in the laboratory or in a special chamber termed the “test chamber”, or in the conditioning chamber, the choice depending on the nature of the test piece and on the test itself. For example, close control of the test atmosphere may not be necessary if the change in properties of the test piece is insignificant over the test period.

NOTE 3 Adapted from ISO 558:1980, definition 2.3.

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

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

3.4
free smoking
condition that exists when the butt end of a cigarette is completely exposed to the atmosphere between successive puffs

3.5
pressure drop
static pressure difference between the two ends of

— the test piece completely encapsulated in a measuring device such that no air can pass through the outer membrane (or wrapping); or

— a pneumatic circuit 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

3.6
draw resistance
negative pressure which has to be applied to the butt end, under test conditions (see ISO 3402) in order to sustain a volumetric flow of 17,5 ml/s, exiting at the butt end, when the cigarette is encapsulated in a measurement device to a depth of 9 mm

NOTE 1 Any ventilation zones and the tobacco rod are exposed to the atmosphere.

NOTE 2 Measurement values are expressed in pascals (Pa). They used to be expressed in millimetres water gauge (mm WG). The values given previously in mm WG are converted into pascals using the following conversion factor: 1 mm WG = 9,8067 Pa.

NOTE 3 The concept of draw resistance may also be subjectively judged when a cigarette is smoked by a consumer/taste panel. Under such circumstances, draw resistance is not measured objectively because the conditions of the formal definition are not met.

3.7
puff duration
interval of time during which the port is connected to the suction mechanism

3.8
puff volume
volume leaving the butt end of a cigarette and passing through the smoke trap

3.9
puff number
number of puffs necessary to smoke a cigarette to a specified butt length

3.10
puff frequency
number of puffs in a given time

3.11
puff termination
termination of the connection of the port to the suction mechanism

3.12
puff profile
flow rate measured directly behind the butt end of a cigarette and depicted graphically as a function of time

3.13
dead volume
volume which exists between the butt end of a cigarette and the suction mechanism

3.14
cigarette holder
device for holding the mouth end of a cigarette during smoking

3.15
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

3.16
port
aperture of the suction mechanism through which a puff is drawn and to which is attached a smoke trap

3.17
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

3.18
compensation
ability to maintain constant puff volumes and puff profiles when the pressure drop at the port changes

3.19
cigarette position
position of a cigarette on the smoking machine

NOTE 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.

3.20
mainstream smoke
all smoke which leaves the butt end of a cigarette during the smoking process

3.21
sidestream smoke
all smoke which leaves a cigarette during the smoking process other than from the butt end

3.22
ashtray
device positioned under the cigarettes in their holders to collect ash falling from the cigarettes during smoking

3.23
clearing puff
any puff taken after the cigarette has been extinguished or removed from the cigarette holder

3.24
ambient air flow
air flow around the cigarettes during the smoking process

NOTE See Annex A.

4 Standard conditions

4.1 Machine pressure drop

The whole of the flow path between the butt end of the cigarette and the suction mechanism shall offer the least possible resistance, and its pressure drop (see 3.5) shall not exceed 300 Pa.

4.2 Puff duration

The standard puff duration (see 3.7) shall be (2,00 ± 0,02) s.

4.3 Puff volume

The standard puff volume (see 3.8) measured in series with a pressure drop device of 1 x (1 ± 5 %) kPa shall be (35,0 ± 0,3) ml. In one puff duration (see 3.7) not less than 95 % of the puff volume shall leave the butt end of the cigarette.

4.4 Puff frequency

The standard puff frequency (see 3.10) shall be one puff every (60 ± 0,5) s measured over 10 consecutive puffs.

4.5 Puff profile

The puff profile (see 3.12) shall be measured with an impedance of 1 x (1 ± 5 %) kPa as specified in 4.3. It shall be bell-shaped 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 25 ml/s and 30 ml/s (see Annex B). At no point shall the direction of flow be reversed.

NOTE Principles of suction mechanisms using a piston pump to obtain the puff profile are given in Annex B.

4.6 Restricted smoking

An analytical smoking machine shall be a restricted smoker [i.e. fulfil the conditions for restricted smoking (see 3.3)].

4.7 Puff number

Each individual puff shall be counted and recorded and the puff number (see 3.9) rounded off to the nearest one-tenth of a puff, based on the puff duration.

4.8 Cigarette holder

The design of the standard cigarette holder (see 3.14) 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.

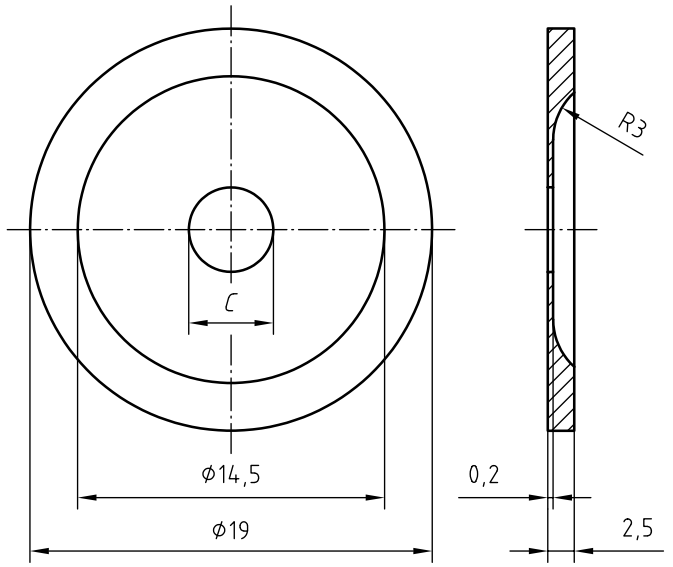
Either the cigarette holder or the smoke trap shall be equipped with a perforated disc (washer) of plain expanded synthetic rubber, closed-cell sponge grade, which partly obstructs the butt end of the cigarette. The synthetic rubber shall have a density of 150 kg/m^3, low swell oil resistance and compression-deflection range of 35 kPa to 63 kPa. Four labyrinth seals shall be used; the one closest to the butt end (back seal) shall be reversed. The dimensions of the washer and labyrinth seals are given in Figure 1. The washer shall be supported by a structure with a hole in its centre of 4 mm diameter.

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.

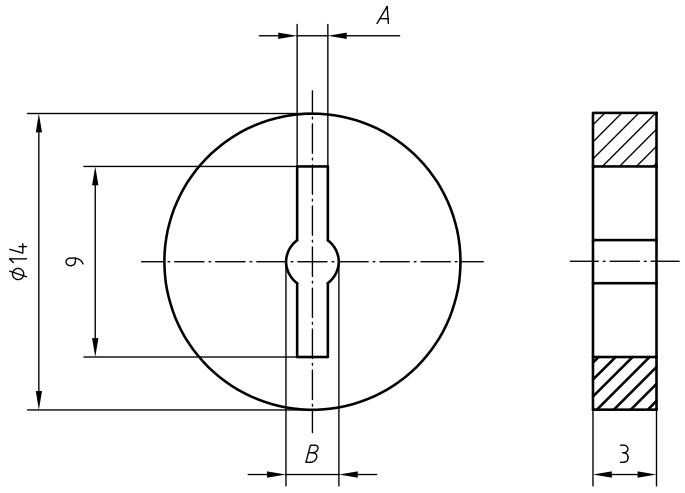
An example of a suitable assembly is given in Figure 2.

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

Dimensions in millimetres



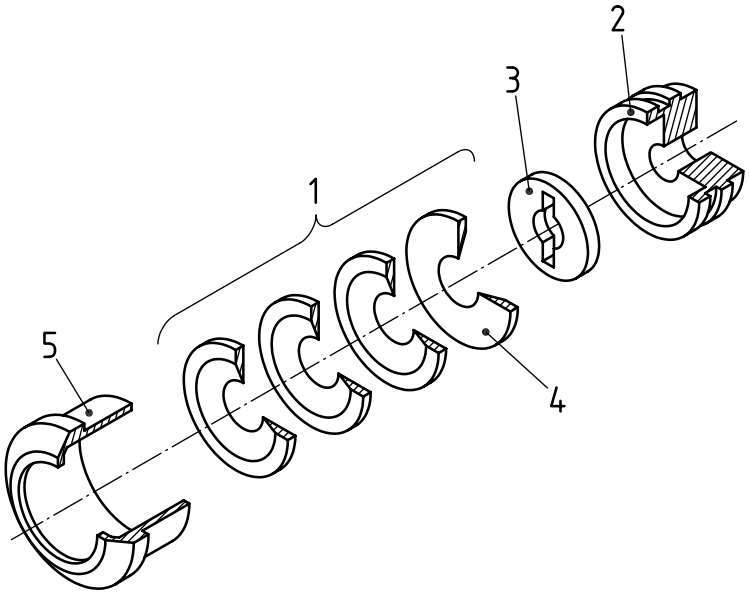
a) Labyrinth seal



b) Washer

Cigarette diameter	A	B	C
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

Figure 1 — Cigarette holder: Labyrinth seal and perforated disc (washer) (dimensional details)



Key

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

NOTE Washer support is for use where a central glass fibre smoke trap is used to trap smoke from more than one cigarette.

Figure 2 — Cigarette holder (schematic)

4.9 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 when inserted.

NOTE See 3.19.

4.10 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.

NOTE See 3.22.

5 Specification for the routine analytical smoking machine

5.1 General

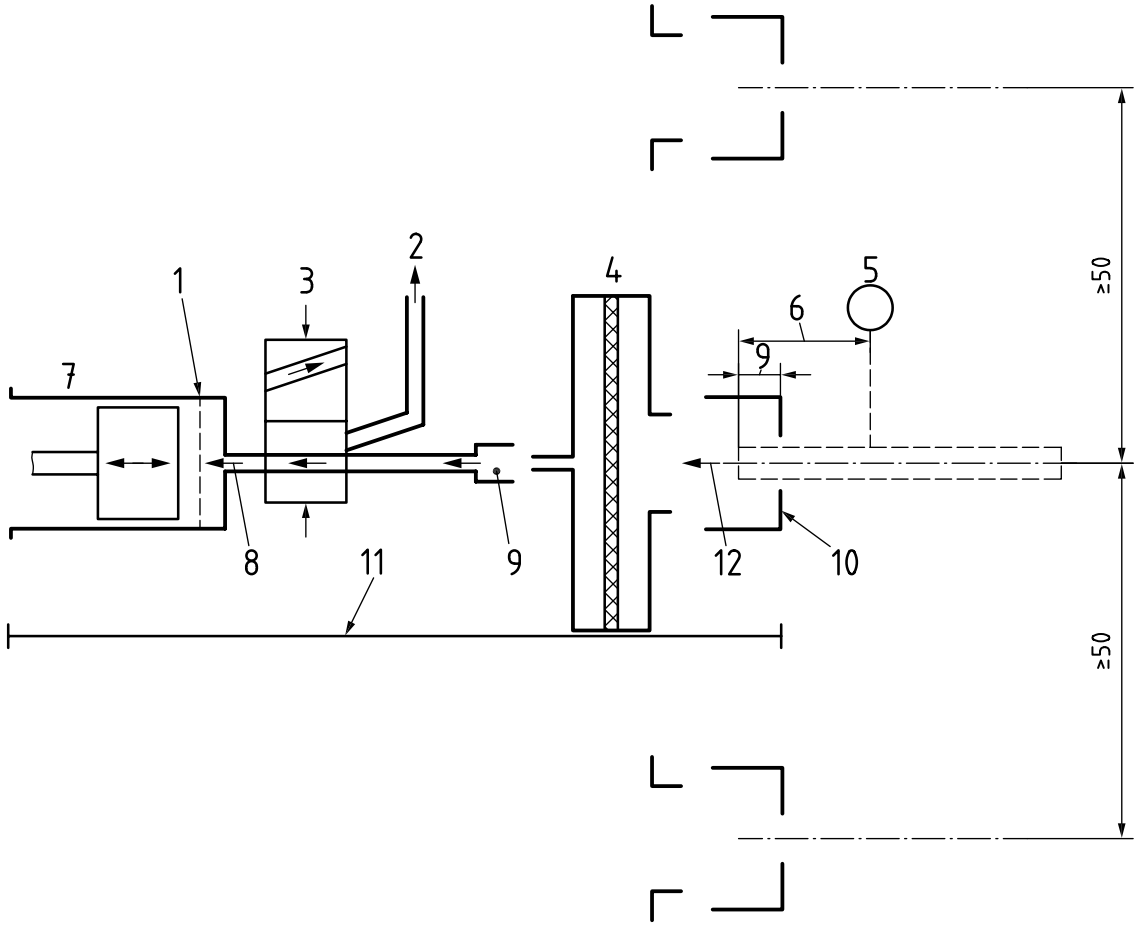
The smoking machine shall comply with the standard conditions (see 4.1 to 4.10) and the special conditions given in 5.2 to 5.8.

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 3.

5.2.2 The machine shall produce a bell-shaped puff profile (see 4.5).

Dimensions in millimetres



Key

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

Figure 3 — Smoking machine schematics

5.2.3 The machine shall be a restricted smoker (i.e. fulfil the conditions for restricted smoking, see 3.3).

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 4.2 to 4.4) during the test for prolonged periods.

5.3.3 The machine shall be capable of sufficient compensation (see 3.18).

When the machine has initially been set to give a puff volume of 35 ml without a pressure drop device, a reduction of no more than 1,5 ml shall be observed when the machine is tested with a pressure drop device of 3 kPa.

5.3.4 The connecting piping between the smoke trap and the suction source shall offer the least possible resistance to flow. The pressure drop of the total flow path between the butt end of the cigarette and the suction source shall not exceed 300 Pa before smoking (see 4.1).

5.3.5 The total dead volume (see 3.13) shall be as small as possible and shall not exceed 100 ml.

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 standard cigarette holders (see 4.8).

5.4.5 The machine shall be designed to hold the cigarettes in the standard position (see 4.9).

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 4.9). 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 disc 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 4.

   Different designs of smoke trap can meet this requirement. It is recommended that for smoking machines where 5 cigarettes are smoked per trap, the diameter of the glass fibre filter should be 44 mm. For machines where 20 cigarettes are smoked per trap, the diameter of the glass fibre filter should be 92 mm.

b) Filter material which shall retain at least 99,9 % of all particles having 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.

Examples of suitable sensors are as follows:

a) 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.

5.4.9 The machine shall be capable of smoking a wide range of cigarettes of different lengths, diameters and cross-sectional shapes while complying 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 International Standard (see Annex A).

5.6 Puff counting

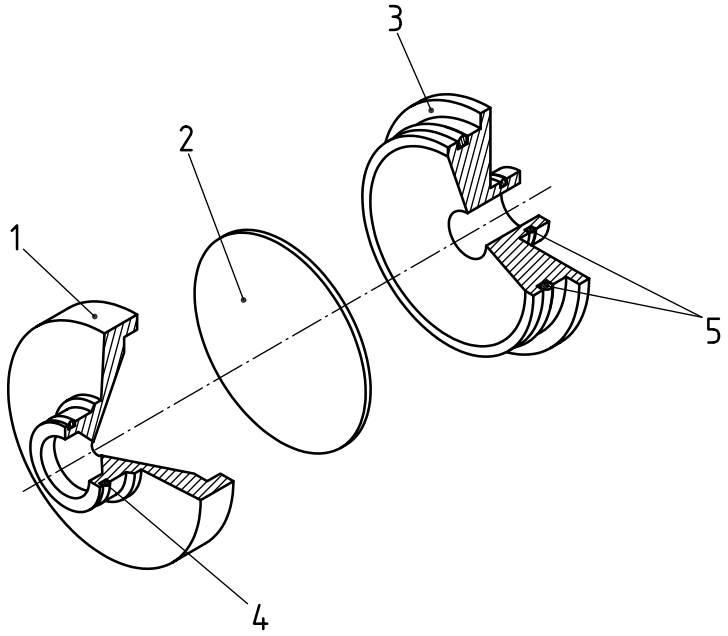
Each port shall have its own puff counter capable of counting to the nearest 0,1 puff (see 4.7).

5.7 Ignition

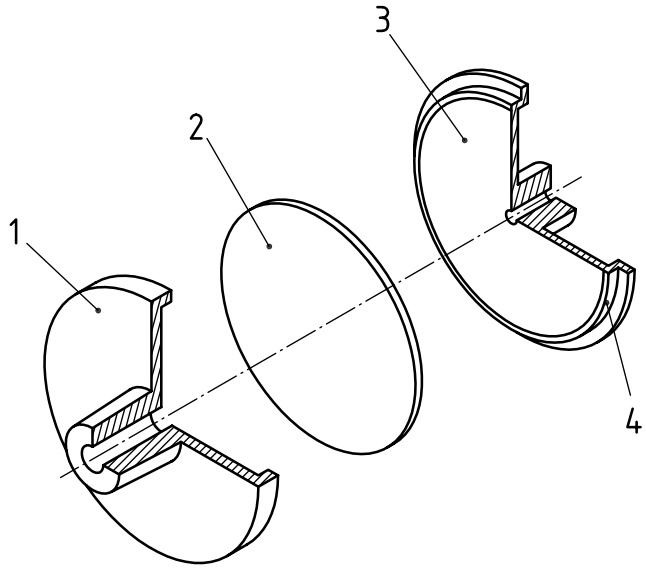
Flameless ignition shall be used. The lighters shall light the cigarettes at the first attempt without either touching or pre-charring the cigarette.

5.8 Smoking enclosure

The smoking process shall be carried out in an enclosure (see A.2), 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 disc
3 GF holder back
4 “O”-ring seal
5 “O”-ring seals

Figure 4 — Examples of glass fibre filter (GF) smoke traps (schematic)

Annex A
(normative)

Ambient air flow around cigarettes in routine analytical smoking machines: Control and monitoring

A.1 Scope

This annex specifies:

— the ambient air velocities surrounding cigarettes in an analytical smoking machine during the smoking process and the mechanical design of the enclosures immediately surrounding them; and

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

NOTE The development of smoking machines has taken place since about 1960. However, because the mechanical configurations which can conform to this International Standard differ greatly, it has been found from the work of a special Task Force established by CORESTA that additional specification of the immediate smoking machine environment is necessary. This leads to better reproducibility in the international interlaboratory comparisons which are often required. It is doubtful if a general mechanical specification could be written to cover all types of smoking machines and so, as well as a general specification, it is necessary to provide examples for the designs most generally used.

There are two principal designs for smoking machines which satisfy the conditions specified in ISO 3308:

— type a) (see Figures A.1 and A.2) 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) (see Figures A.3 to A.5) in which the position of the puff termination device is fixed, i.e. adjustments are made by moving the cigarette and its holder.

A.2 Examples of designs of smoking machine enclosures

A.2.1 Smoking machines, type a)

Figures A.1 and A.2 show schematic designs of the enclosure, including the features which shall be incorporated.

A.2.2 Smoking machines, type b)

Examples of this type of machine exist with 20 channels and 8 channels. Features common to both are shown in detail in Figure A.3. Figure A.4 shows a schematic design of the enclosure, including the features which shall be incorporated in 20-channel versions. Figure A.5 is appropriate to 8-channel versions.

A.3 Air velocity measurement locations

A.3.1 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.

A.3.2 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 mouth end of the cigarette.

A.3.3 Smoking machines, type b)

A.3.3.1 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.

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

A.3.3.2 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.

A.4 Specification of the air velocity meter

An air velocity meter capable of an 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.

A.5 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.

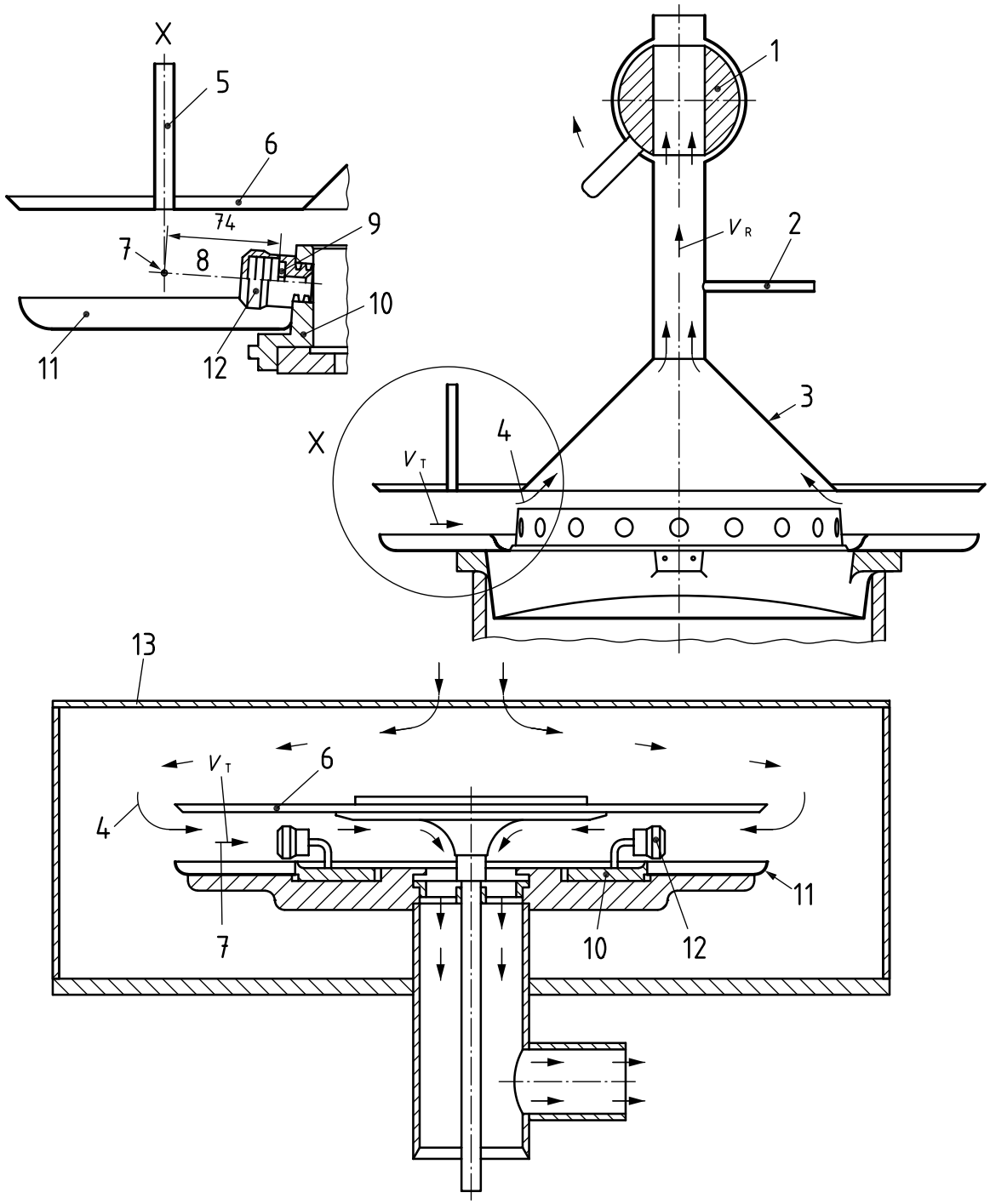
For smoking machines type b), the air velocity measured at an individual port should be within the range of 150 mm/s to 250 mm/s.

A.6 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.

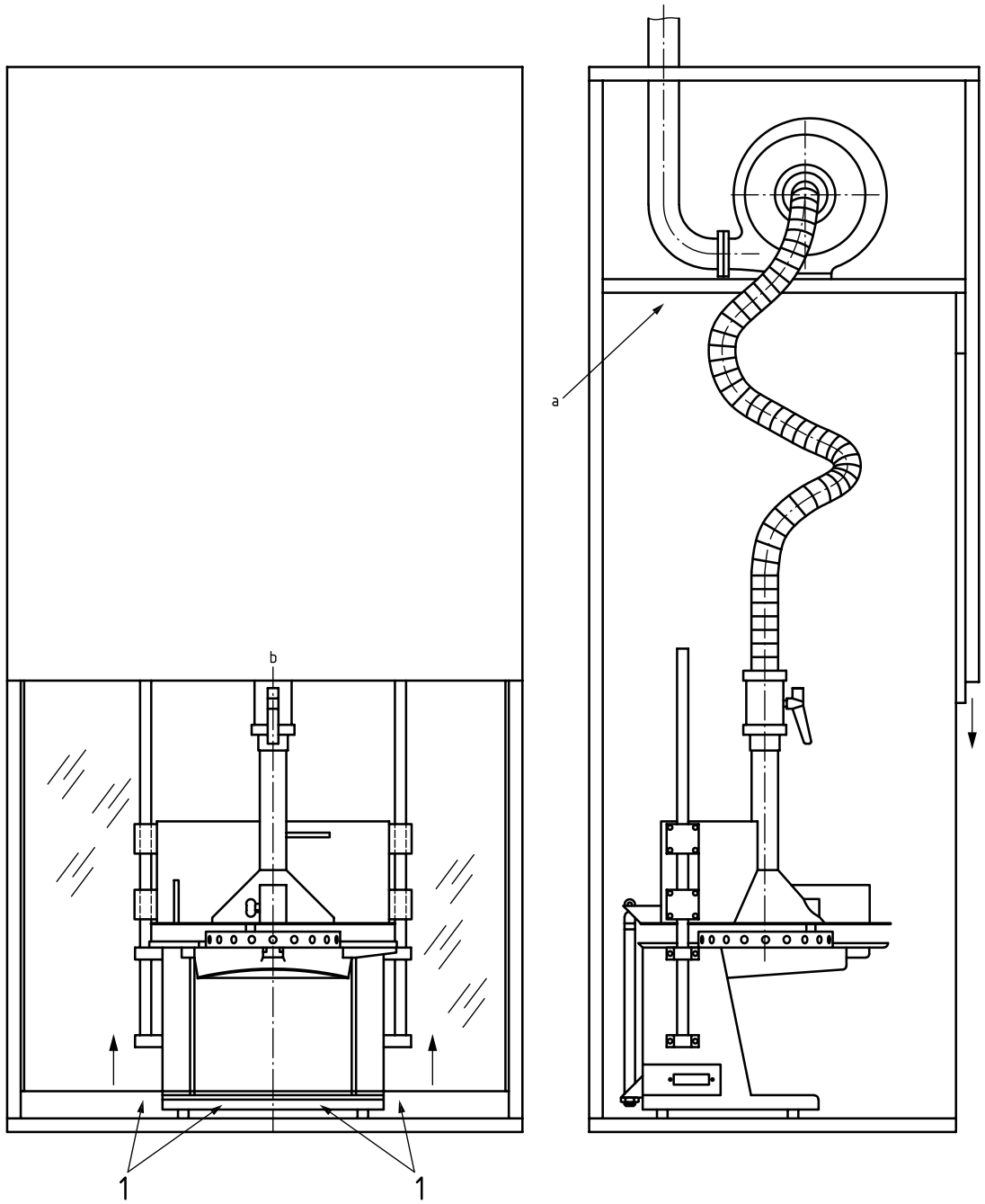
Dimensions in millimetres



Key

1	ball valve	8	cigarette centre
2	sensor guide pipe	9	polychloroprene washer
3	extraction hood	10	smoking ring
4	air flow (schematic)	11	ashtray
5	sensor guide pipe	12	cigarette holder
6	hood	13	enclosure
7	reference air velocity measurement position		
V_T	Air velocity around the cigarette	V_R	Air velocity in the extraction duct

Figure A.1 — Machines with fixed cigarette position: Rotary smoking machines type a)



Key

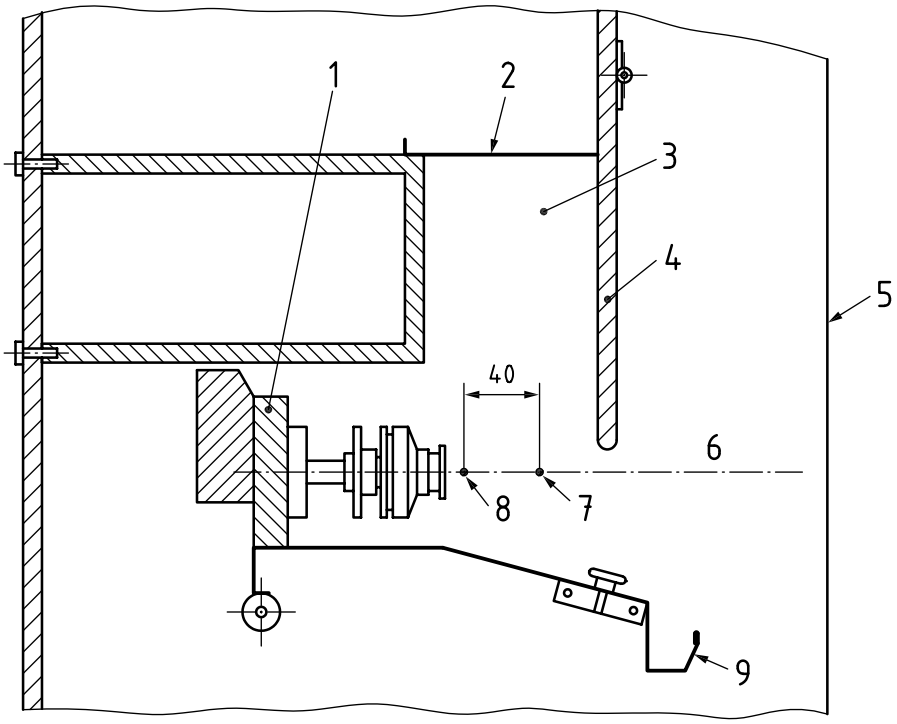
1 air

a The enclosure should not be open at the top.

b The front flap should be in the closed position during smoking.

Figure A.2 — Example of an enclosure for a rotary smoking machine type a) with hood

Dimensions in millimetres

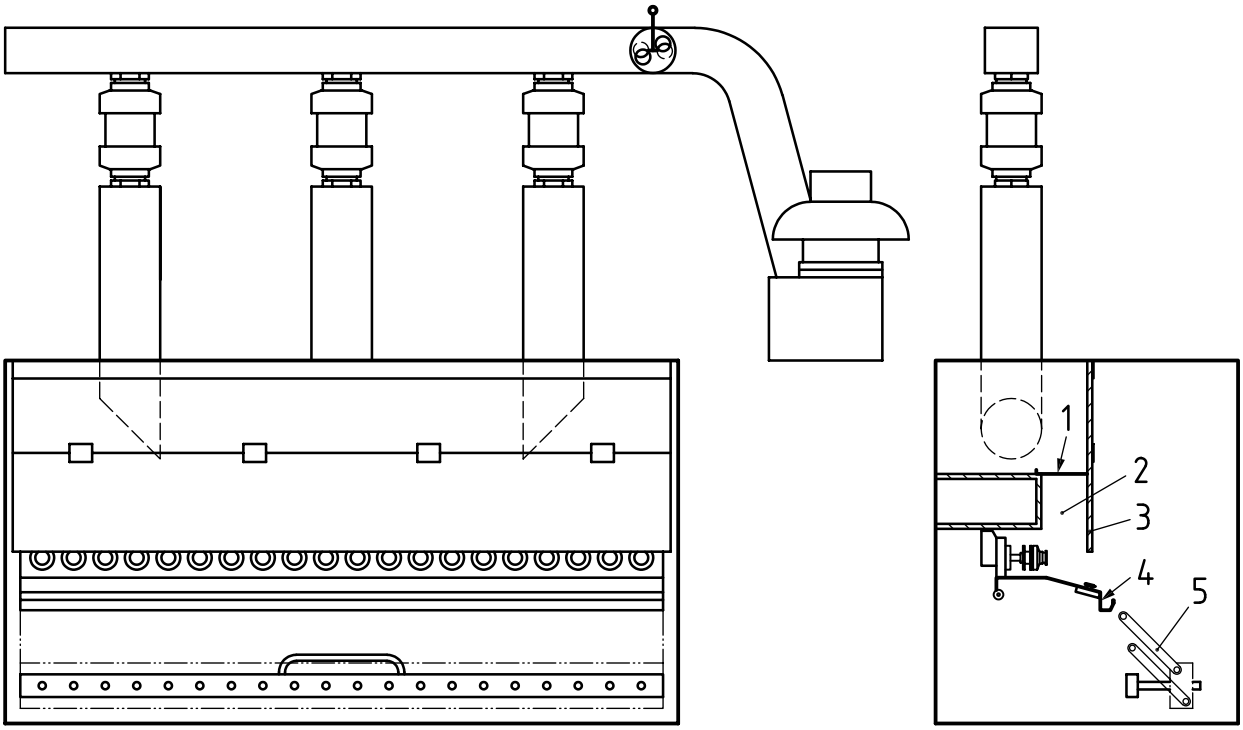


Key

1 smoking bar
2 baffle plate
3 internal duct
4 hinged front flap
5 front of smoking machine
6 nominal cigarette centre height
7 reference air velocity measurement position
8 puff termination position
9 ashtray

NOTE This view shows the relationship between the puff termination position, smoking bar and ashtray.

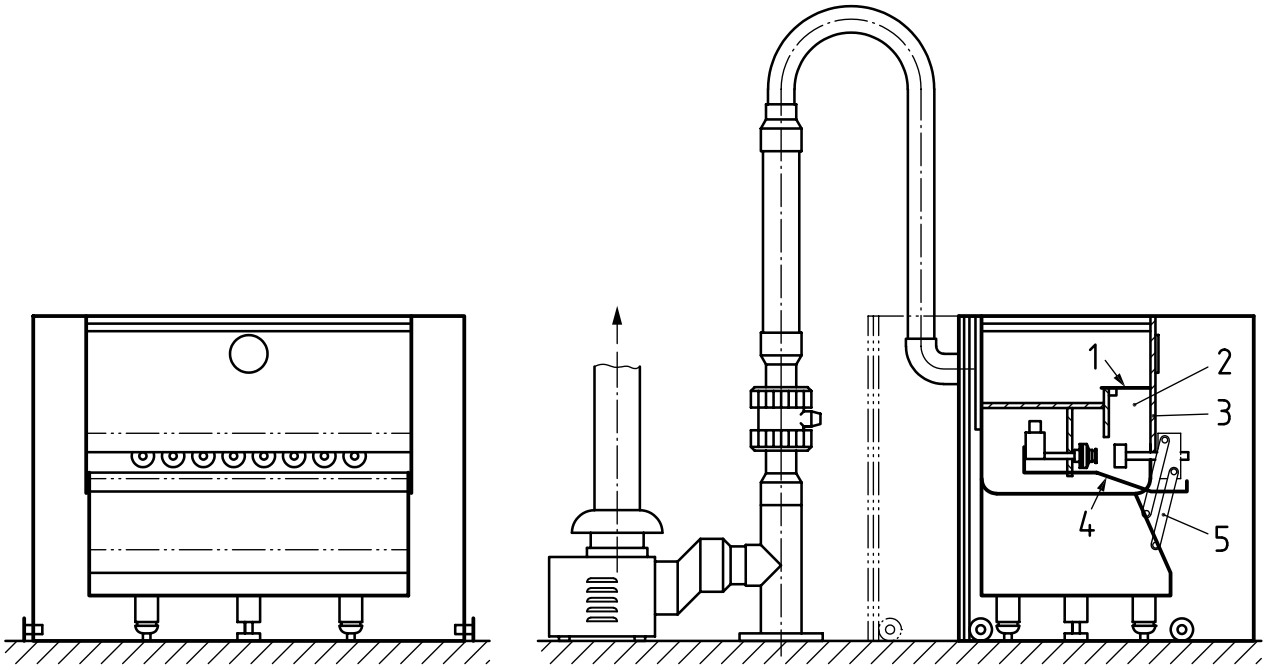
Figure A.3 — Smoking machine type b) with fixed puff-termination position



Key

1 baffle plate
2 internal duct
3 hinged front flap
4 ashtray
5 lighter bar

Figure A.4 — Schematic view of a 20-channel linear machine type b)



Key

1 baffle plate
2 internal duct
3 hinged front flap
4 ashtray
5 lighter bar

Figure A.5 — Schematic view of an 8-channel linear machine type b): General view without carbon monoxide collection

Annex B
(informative)

Description of the puffing mechanism of a piston-type smoking machine

B.1 Scope

This annex describes the use of the piston principle but it is not intended to preclude or restrict the future development of smoking machines.

B.2 Principle of the puffing mechanism

Examples of piston/crankshaft mechanisms are given in Figure B.1.

B.3 Special considerations

B.3.1 Total swept volume

The total swept volume is the volume of air displaced when the piston passes from the top dead centre to the bottom dead centre. It may be up to 3 % greater than the puff volume. A typical example of the resultant swept profile is given in Figure B.2.

B.3.2 Puff volume

The puff volume may be controlled by truncating the "skirt" or "tails" of the swept profile using a valve.

B.4 Design considerations of the puffing mechanism

B.4.1 It would appear that specifications of A, r, l and h (see Figure B.1) are the most important design considerations. Since 2 Ar equals swept volume, r is automatically fixed and l and h determine the shape of the puff. For reasons of symmetry, l and h should be as large as possible. Therefore, in the manufacture of a piston-type smoking machine, the recommendations given in B.4.2 to B.4.6 should apply.

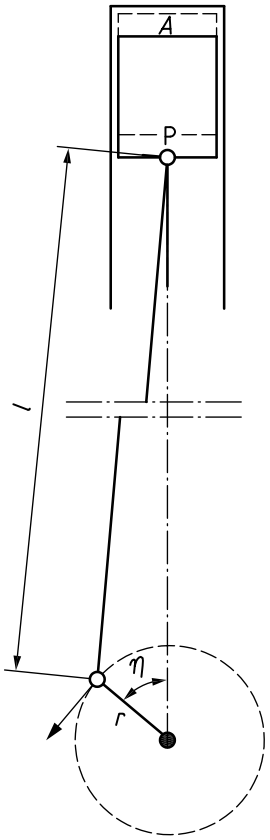
B.4.2 The speed of rotation of the shaft should be constant during puffing. It should be fully adjustable and should have a fine control.

B.4.3 It is desirable that pistons and cylinders be completely interchangeable.

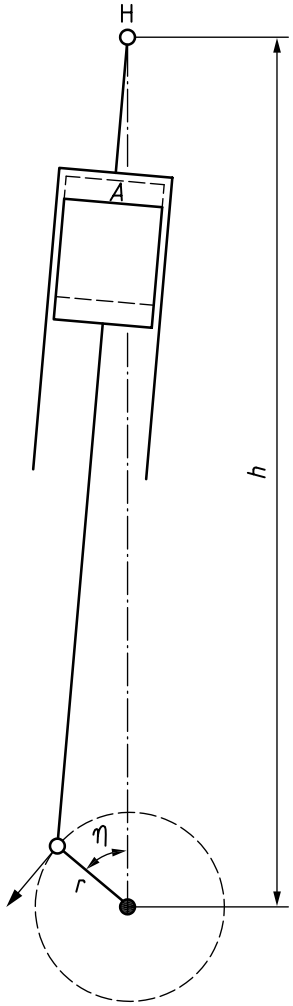
B.4.4 The distance l or h should be greater than 10 r.

B.4.5 The piping between the smoke trap and the cylinder should offer the least possible pressure drop (see 5.3.4).

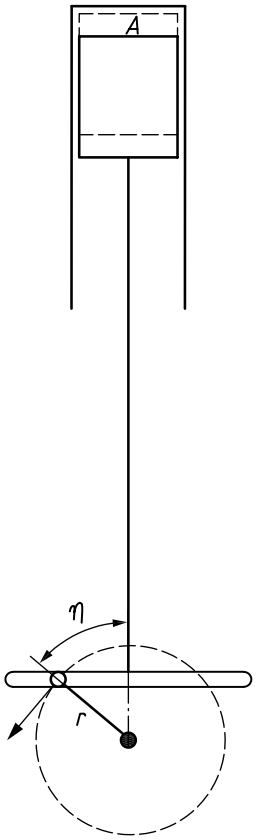
B.4.6 In order to ensure that the machine performs in accordance with the specification, incorporation of a mechanism to start or stop the piston at a definite point may be necessary.



a) Conventional crankshaft with connecting rod and small end



b) Rigid piston connected with cylinder pivoted at H

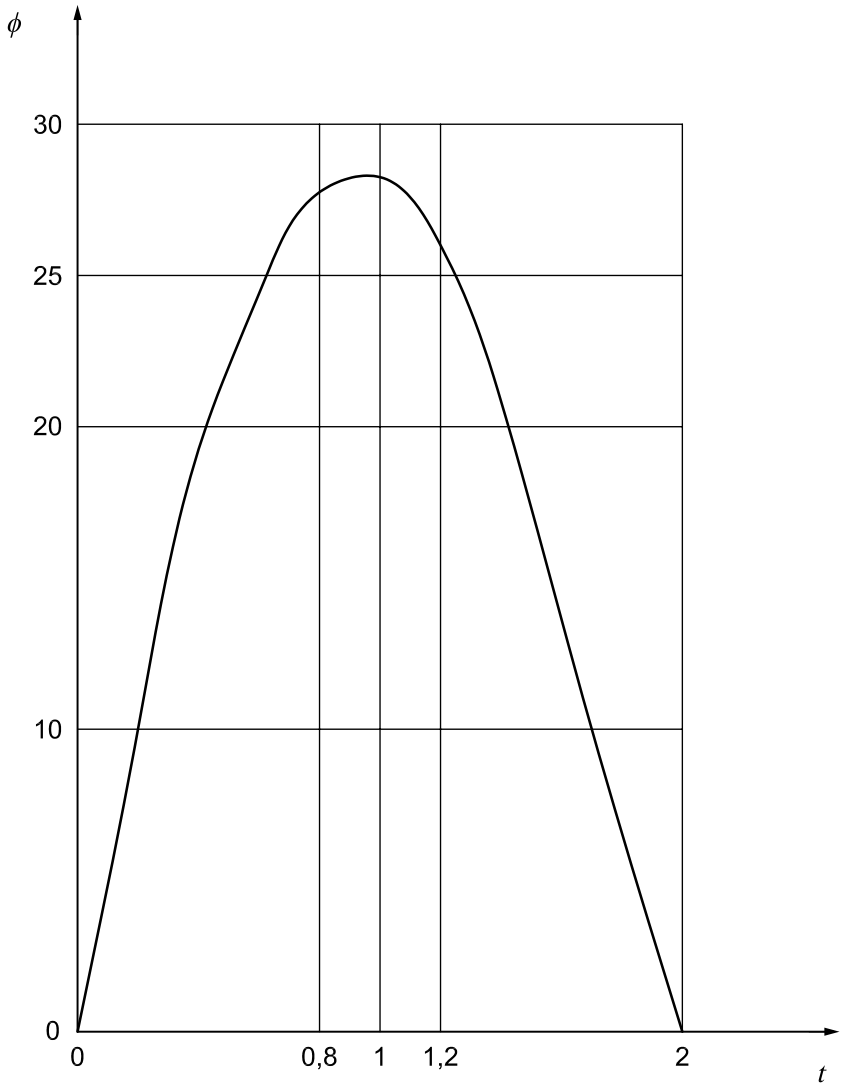


c) Symmetrical piston movement

Key

H, P	pivots	*h*	distance between crank and pivot H
A	area of cross-section	*r*	radius of crank
l	length of connection rod	*η*	angular displacement of the crankshaft

Figure B.1 — Examples of piston/crankshaft mechanisms



Key

Φ flow rate, ml/s
t time, s

Figure B.2 — Typical puff profile without cigarette (swept profile)

Annex C
(informative)

Diagrammatic representation of a puff profile

C.1 To illustrate certain definitions and certain standard conditions, an example of a puff profile is shown in Figure C.1.

At time $t = 0$, suction may be applied to the cigarette by means of a piston pump. The resulting flow rate Φ at the butt end of the cigarette varies to give a bell-shaped puff profile. The maximum flow rate Φ_m is reached at time t_m. The flow rate then decreases during the puff duration to reach the value Φ_d at time t_d when the puffing source ceases to apply suction, but a pressure differential still exists.

Finally, the flow rate decreases slowly to zero, a value reached at time t_e.

C.2 The standard puff profile has its maximum so that

$$25 \text{ ml/s} \leq \Phi_m \leq 30 \text{ ml/s}$$

at time t_m so that

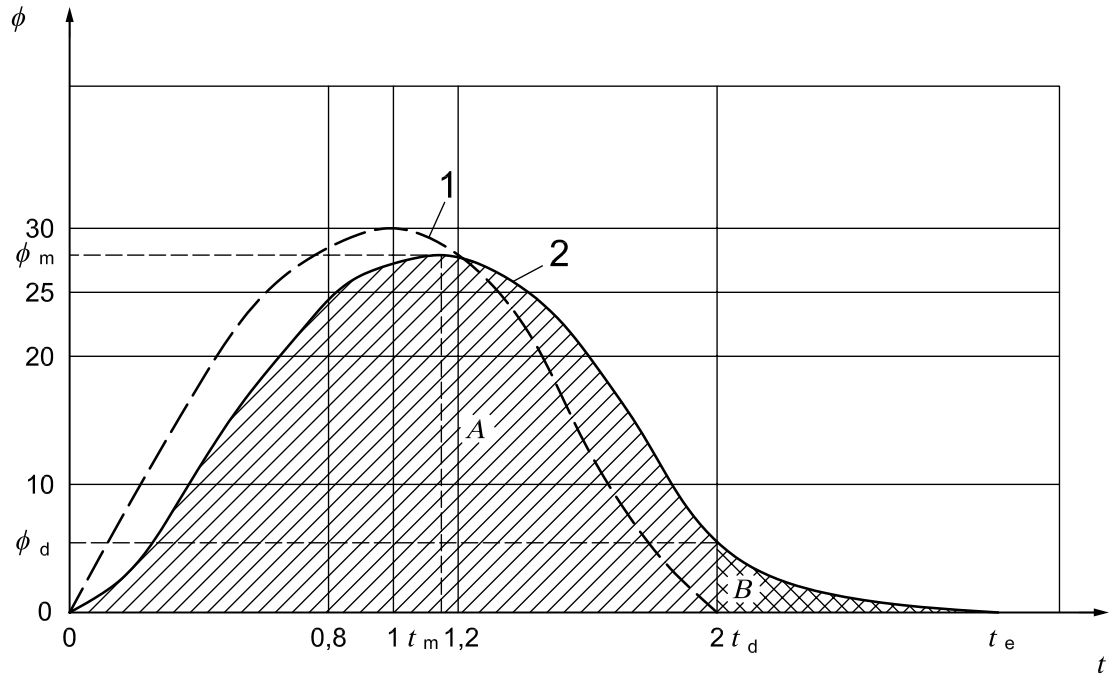
$$0{,}8 \text{ s} \leq t_m \leq 1{,}2 \text{ s}$$

The standard puff duration is t_d = 2 s and the time t_e is consequently limited by the standard puff frequency to t_e = 60 s.

The puff volume, V, may be calculated on the basis of the shaded area in Figure C.1 from the formula:

$$V = \int_0^{t_e} \Phi(t)\,dt = A + B = \int_0^{t_d} \Phi(t)\,dt + \int_{t_d}^{t_e} \Phi(t)\,dt$$

The consequence of the standard conditions is the following:



V=35 ml

$$A = \int_0^{t_d} \Phi(t)\,dt \geq 0{,}95\,V$$

Key

1 swept profile
2 puff profile
Φ flow rate, ml/s
t time, s

Figure C.1 — Diagrammatic representation of a puff profile with cigarette

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