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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
ISO 3308:1991(E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

This third edition cancels and replaces the second edition (ISO 3308:1986), which has been technically revised as a result of an extensive examination of the smoking machine performance by members of CORESTA.

Major changes have also been made: subclause 4.8 now specifies the use of a perforated disc (washer) in order that all types of cigarettes may be smoked; subclause 4.10 (specification of the ashtray position); and the inclusion of a new annex A which sets out the conditions for the control of the ambient air flow around cigarettes in smoking machines.

As a result of the changes, members of CORESTA have found increased accuracy and precision and have been able to provide data for incorporation in ISO 4387:1991, *Cigarettes — Determination of total and nicotine-free dry particulate matter using a routine analytical smoking machine*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.

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Introduction

This International Standard describes the requirements found necessary to be specified in the light of knowledge and experience gained with analytical cigarette-smoking machines.

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Routine analytical cigarette-smoking machine — Definitions and standard conditions

1 Scope

This International Standard

- defines the smoking parameters and specifies the standard conditions to be provided for the routine analytical machine smoking of cigarettes;
- specifies the requirements of a routine analytical smoking machine complying with the standard conditions.

NOTE 1 Annex A specifies the ambient air velocities surrounding cigarettes in a routine analytical smoking machine; mechanical design of the enclosures immediately surrounding them; and the methods of air velocity measurement, including the location where air velocity shall be measured.

Annex B describes, by way of 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 standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3402:1991, *Tobacco and tobacco products — Atmosphere for conditioning and testing*.

ISO 4387:1991, *Cigarettes — Determination of total and nicotine-free dry particulate matter using a routine analytical smoking machine*.

ISO 6565:1983, *Tobacco and tobacco products — Draw resistance of cigarettes and filter rods — Definitions, standard conditions and general aspects*.

ISO 7210:1983, *Smoking machines for tobacco and tobacco products — Non-routine test methods*.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 ambient conditions: The whole of the variable parameters physically characterizing the conditions in the room and environment in which the analytical smoking is carried out.

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

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

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

3.5 pressure drop: The difference in static pressure between any two points of the pneumatic circuit of a smoking machine which are passed by a current of air at a constant flow rate of 17,5 ml/s.

NOTE 2 The term **draw resistance** has a very similar meaning. To avoid any confusion, the term **draw resistance** is used for cigarettes and filter rods, whereas the term **pressure drop** is used by analogy in the case of the pneumatic circulation in a smoking machine.

3.6 puff duration: The interval of time during which the port is connected with the suction mechanism.

3.7 puff volume: The volume leaving the butt end of a cigarette and passing through the smoke trap.

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

3.9 puff frequency: The number of puffs in a given time.

3.10 puff termination: The ending of the connection of the port with the suction mechanism.

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

3.12 dead volume: The volume which exists between the butt end of a cigarette and the suction mechanism.

3.13 cigarette holder: The device for holding the mouth end of a cigarette during smoking.

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

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

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

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

3.18 cigarette position: The position of a cigarette on the smoking machine. 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.

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

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

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

3.22 clearing puff: Any puff taken after the cigarette has been extinguished or removed from the cigarette holder.

4 Standard conditions

4.1 Machine pressure drop (3.5)

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 shall not exceed 300 Pa.

4.2 Puff duration (3.6)

The standard puff duration shall be 2,0 s, with a standard deviation of not greater than 0,05 s for individual puffs.

4.3 Puff volume (3.7)

The standard puff volume measured in series with a pressure drop device of 1 kPa shall be 35 ml with a standard deviation for individual puffs not greater than 0,15 ml. In one puff duration (3.6) not less than 95 % of the puff volume shall leave the butt end of the cigarette.

4.4 Puff frequency (3.9)

The standard puff frequency shall be one puff every 60 s with a standard deviation for this time not greater than 0,5 s.

4.5 Puff profile (3.11)

The puff profile, when measured on an unlit cigarette, 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 3 Principles of suction mechanisms using a piston pump to obtain the puff profile are given in annex B.

4.6 Restricted smoking (3.3)

An analytical smoking machine shall be a restricted smoker.

4.7 Puff number (3.8)

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.

4.8 Cigarette holders (3.13)

The standard cigarette holder shall cover 9 mm $\pm$ 0,5 mm from the butt end of a cigarette and shall be impermeable to smoke components and to

air. The standard cigarette holder shall ensure that the leakage between the cigarette and cigarette holder is not greater than 0,5 % of the puff volume.

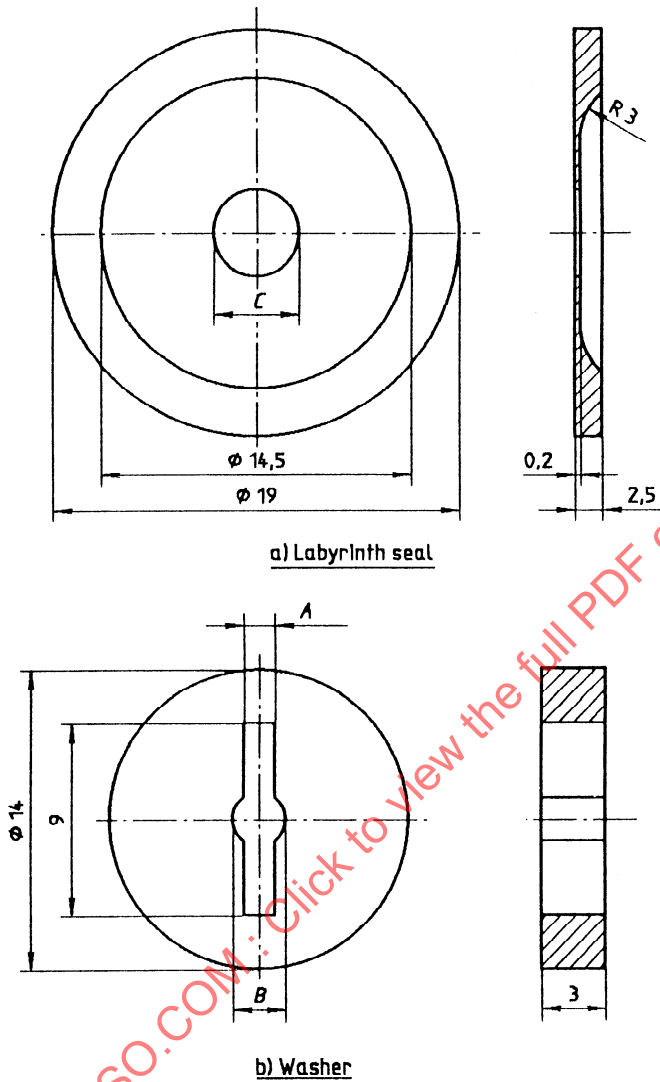
Either the cigarette holder or the smoke trap shall be equipped with a perforated disc (washer) of plain expanded synthetic rubber, closed cell sponge grade, which partly obstructs the butt end of the cigarette. The synthetic rubber shall have a density of 150 kg/m^3 to 170 kg/m^3 , low swell oil resistance 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 assembly shall be constructed so that the cigarette shall be in contact with the washer when the cigarette is inserted to a depth of 9 mm from the sealing annulus of the front labyrinth seal.

NOTE 4 An example of a suitable assembly is given in figure 2.

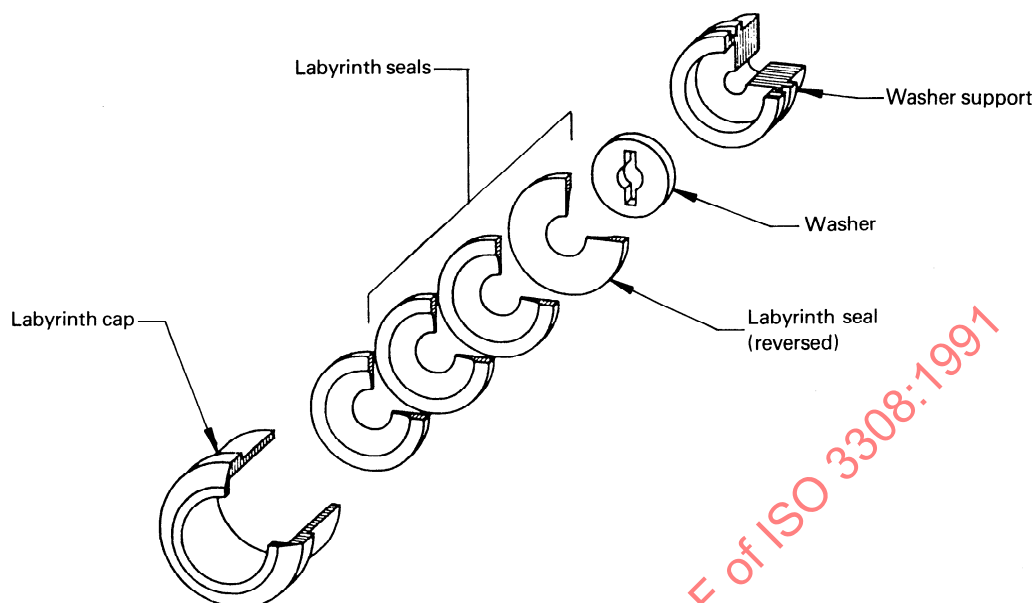
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Dimensions in millimetres



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)



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 (3.18)

The angle formed by the longitudinal axis of the cigarette and the horizontal plane shall be as small as possible; it shall not exceed 10° if the centre of the butt end is lower than the centre of the other end, and 5° if the centre of the butt end is higher than the centre of the other end.

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

4.10 Ashtray position (3.21)

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

The smoking machine shall comply with the standard conditions (see 4.1 and 4.10) and the following special conditions.

5.1 Operating principle and puff profile

The machine shall include a device to draw a fixed volume of air (puff) through a cigarette.

NOTE 5 A schematic diagram is shown in figure 3.

Dimensions in millimetres

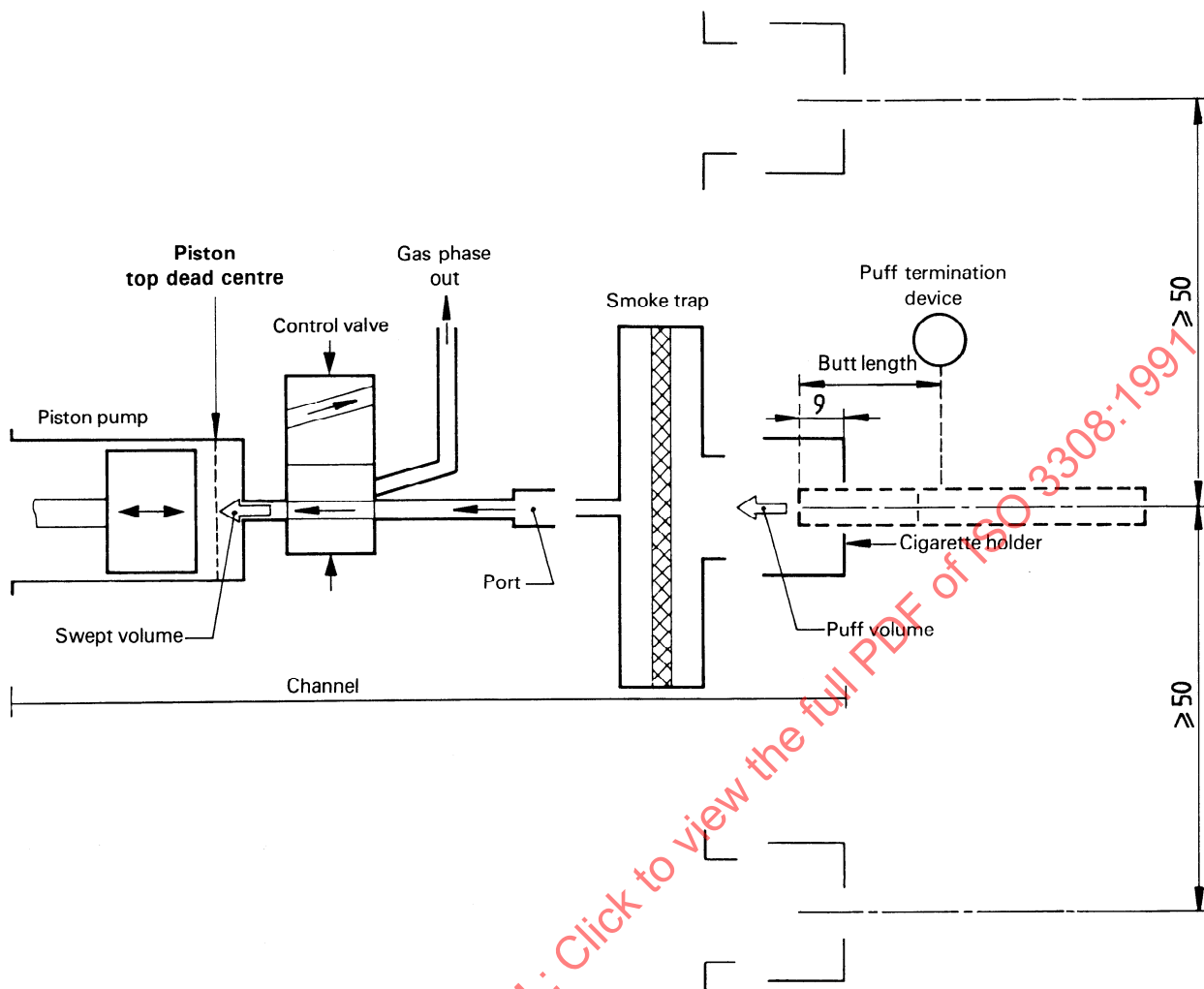


Figure 3 — Smoking machine schematics

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

5.1.2 The machine shall be a restricted smoker (3.3).

5.2 Reliability and compensation

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

5.2.1 The machine shall possess the mechanical and electrical reliability necessary to meet the standard conditions regarding these parameters (see 4.2 to 4.4) for prolonged periods.

5.2.2 The machine shall be capable of sufficient compensation (3.17).

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.

5.2.3 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).

5.2.4 The total dead volume (3.12) shall be as small as possible and shall not exceed 100 ml.

5.3 Cigarette holders and smoke traps

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

5.3.1 The cigarette holders shall be capable of holding the butt end of the cigarette during smoking. The standard conditions relative to the length of butt covered by this device and the airtightness of the seal shall be as given in 4.8.

Labyrinth seals shall be used for attaching cigarettes.

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

NOTE 6 A screwed fitting or "O" ring seal is recommended. Rubber tubing is considered to be unsatisfactory.

5.3.3 The cigarettes to be smoked shall be attached to the ports or the smoke traps by standard cigarette holders (see 4.8).

5.3.4 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.

5.3.5 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.

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

- Filter holder made of an airtight, non-hygroscopic and chemically inert material, preferably transparent, fitted with end-cap seals of the same 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.

NOTES

7 Two examples are given in figure 4.

8 Different designs of smoke trap can meet this requirement. It is recommended that for smoking machines where five 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.

- Filter material which shall retain at least 99,9 % of all particles having a diameter equal to or greater than $0,3 \mu\text{m}$ 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 polyacrylate binder shall not exceed 5 % (m/m).

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.

5.3.7 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.

The sensor may be either

- a) a micro-switch activated by the burning through of a 100 % cotton, 40 denier thread, placed on the butt mark; or
- b) a specially shielded infrared detector.

5.3.8 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.

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

5.4 Ambient conditions

The ambient conditions 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 ambient conditions shall correspond to those specified in ISO 3402:

- Temperature $22 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$
- Relative humidity $(60 \pm 5) \%$

The linear air speed around the cigarettes shall be adjustable such that sidestream smoke can be effectively removed.

NOTE 9 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).

5.5 Puff counting

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

5.6 Ignition

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

5.7 Smoking enclosure

The smoking process shall be carried out in an enclosure, 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.

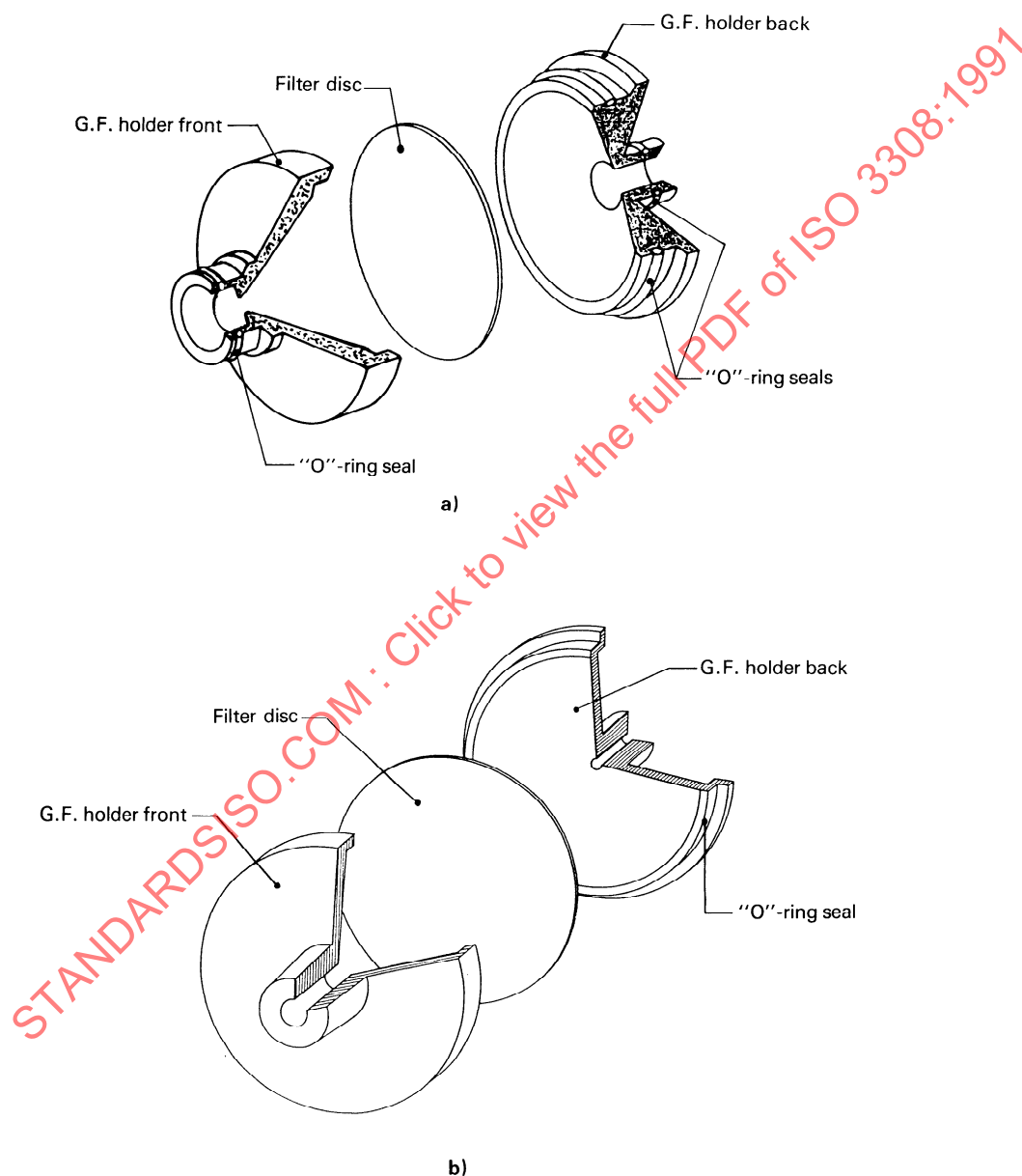


Figure 4 — Glass fibre filter (G.F.) smoke trap (schematic)

Annex A (normative)

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

A.1 Introduction

The development of smoking machines has taken place over the past 40 years. However, because the mechanical configurations which can meet 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 inter-laboratory comparisons which are often required. It is doubtful if a general mechanical specification can be written to cover all types of smoking machine 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 which satisfy 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 Scope

This annex

- specifies the ambient air velocities surrounding cigarettes in an analytical smoking machine during the smoking process and in the mechanical design of the enclosures immediately surrounding them;
- specifies the methods of air velocity measurement and the location where air velocity shall be measured.

A.3 Design of smoking machine enclosure

Examples of mechanical specifications for the design of suitable enclosures are as follows.

A.3.1 Smoking machines, type a)

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

A.3.2 Smoking machines, type b)

This type of machine exists with 20 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.4 Air velocity measurement locations

The reference points at which the measurement of air velocity shall be made are given. Cigarette holders, but not cigarettes, shall be in place during measurements. 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.4.1 Smoking machines, type a)

The air velocity shall be measured at a point on the axis of the cigarette as held in its holder 74 mm towards the end of the cigarette which is to be lit from a datum defined by the position of the butt (mouth) end of the cigarette.

A.4.2 Smoking machines, type b)

A.4.2.1 The air velocity shall be measured 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.

A.4.2.2 In order to check the uniformity of air flow across the smoking machine, measurements shall be made at least daily at a central port and at a port near each extreme. Additional measurements may be required upon installation or relocation of the machine.

A.5 Specification of the air velocity meter

An air velocity meter capable of an accuracy of not less than 20 mm s^{-1} at 200 mm s^{-1} 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.

NOTES

10 An omnidirectional probe is preferred.

11 Suitable meters are made by Lambrecht GmbH and TSI Inc.¹⁾.

A.6 Standard value of air velocity

The standard value of the air velocity shall be 200 mm s^{-1} .

A.7 Setting and checking air velocity

Air velocity shall be set at the standard value at least daily. It is normal practice to measure and, if required, to adjust the air flow in ducts so that the standard air velocity at the reference point is achieved.

NOTES

12 Laboratory procedures should aim to ensure that the air velocity average during a smoking run lies in the range $200 \text{ mm s}^{-1} \pm 30 \text{ mm s}^{-1}$.

13 For smoking machines, type b), the air velocity measured at an individual port should be within the range $200 \text{ mm s}^{-1} \pm 50 \text{ mm s}^{-1}$.

14 Extreme external atmospheric conditions, e.g. high wind velocity, wide relative humidity variations, may affect air flow conditions in smoking machine enclosures. In such circumstances more frequent checks of air velocity should be made.

A.8 Subsidiary method of use

When it is not possible to obtain and use the equipment to satisfy A.6 and A.7, confirmation of the achievement of the standard smoking conditions can be obtained by test smoking cigarettes, the yield of which has been previously determined. If this subsidiary method of test has been used, a note to this effect shall be made in the test report, ISO 4387:1991, clause 8.

A.8.1 Use of reference cigarette

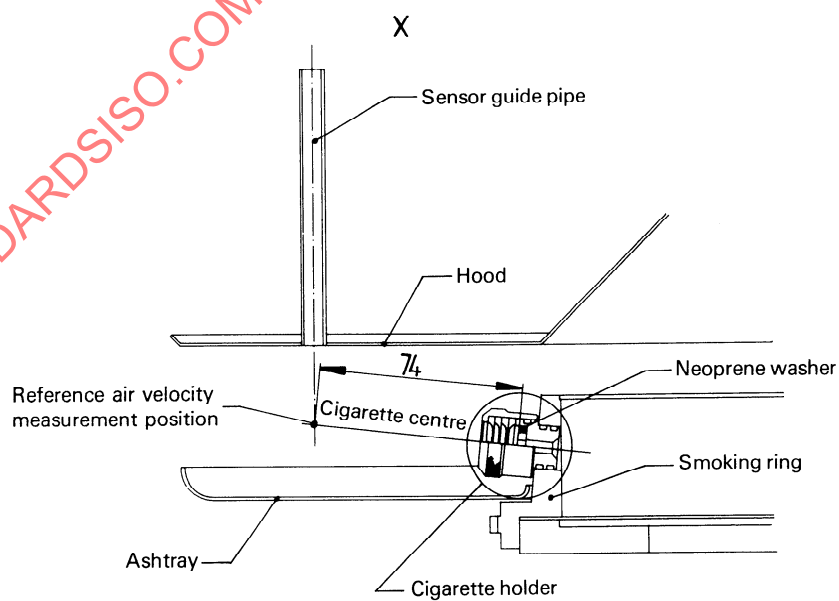
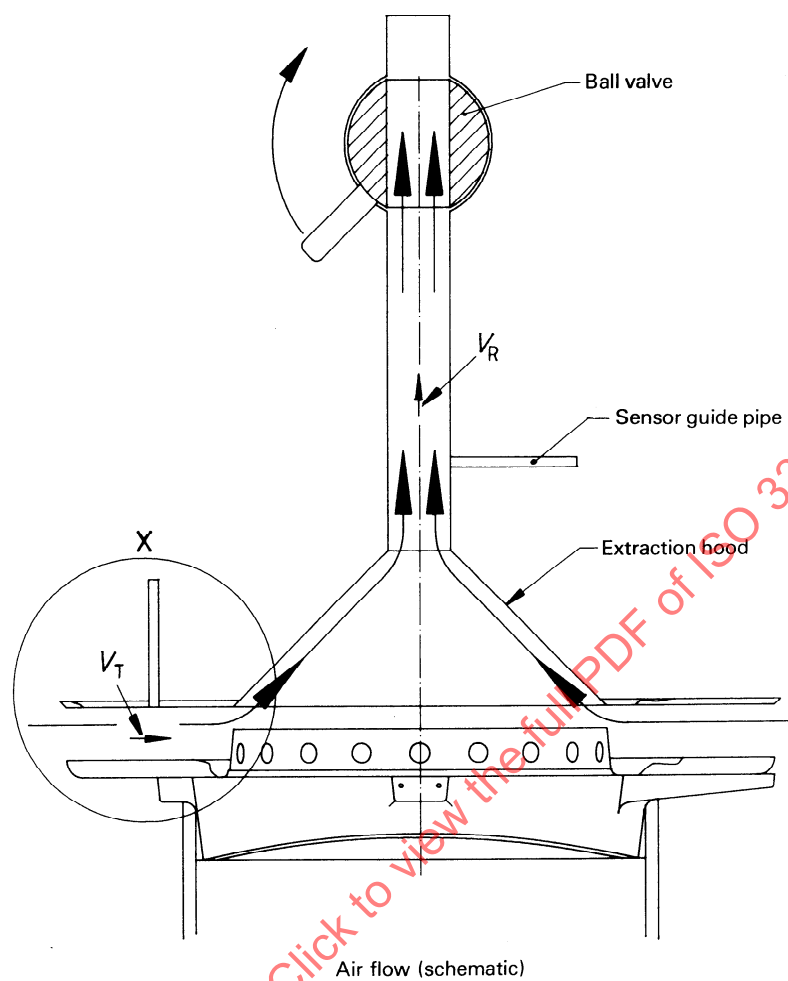
A.8.1.1 A large batch of reference cigarettes should be made and extensively tested in accordance with the method given in ISO 4387. Mean data for nicotine-free dry particulate matter and nicotine with confidence levels about the mean should be derived.

A.8.1.2 A sample of these cigarettes should be smoked in accordance with ISO 4387 and the data compared with the reference values A.8.1.1. Air velocity may be judged to be correct if the values obtained from the trial smoking when compared with the reference value for nicotine-free dry particulate matter are consistent with the repeatability and reproducibility given in ISO 4387, clause 9. In the event of discrepancies greater than these, the air flow controls should be adjusted until the values are consistent.

NOTE 15 Care must be taken when using this subsidiary method of test to ensure that all other controls of the smoking machine and smoking process are correctly established before adjusting the flow controls.

1) This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Dimensions in millimetres



V_T = Air velocity around the cigarette
 V_R = Air velocity in the extraction duct

Figure A.1 — Machine with fixed cigarette position — Rotary smoking machine

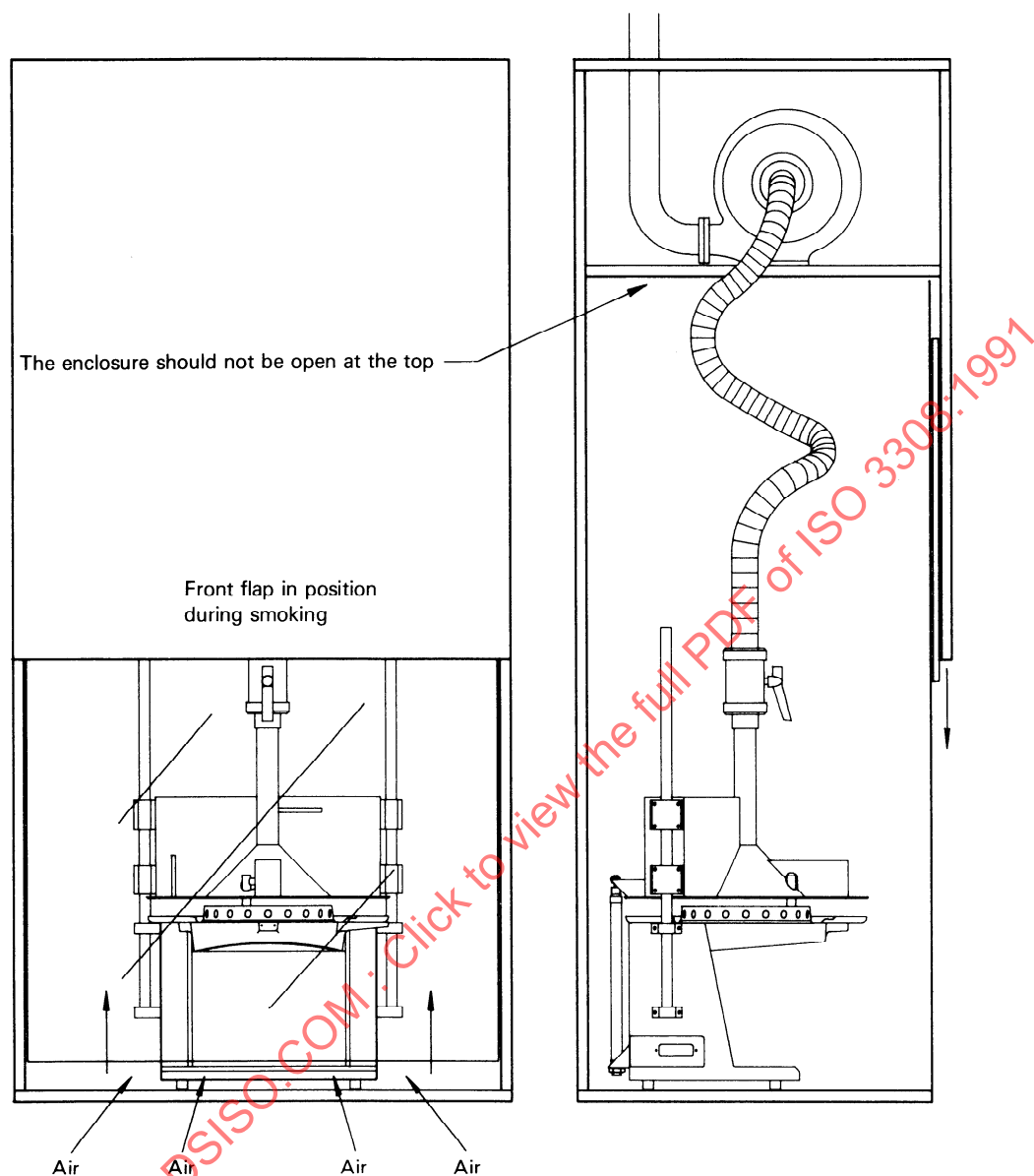
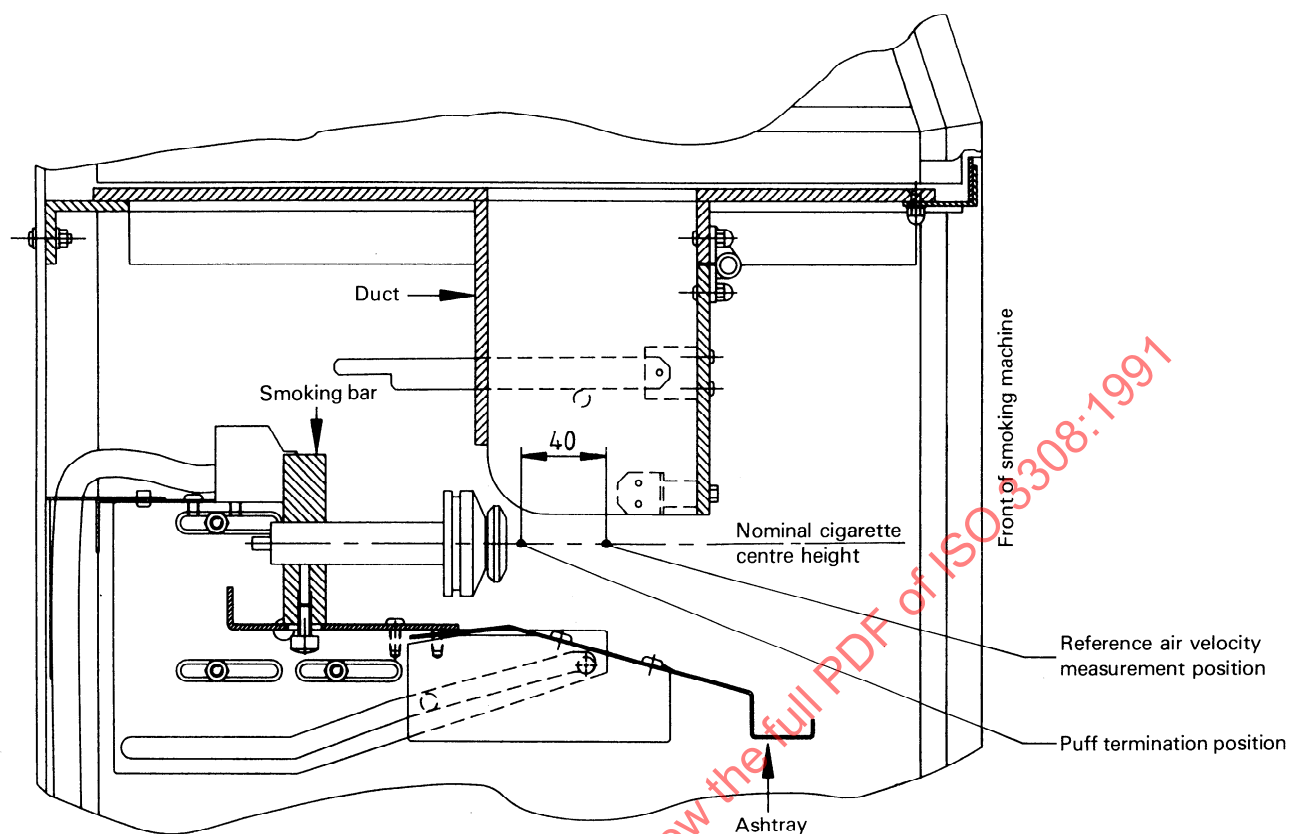


Figure A.2 — Example of an enclosure for a rotary smoking machine with hood

Dimensions in millimetres



View showing relationship between
puff termination position, smoking bar,
and ashtray

Figure A.3 — Machine with fixed puff termination position

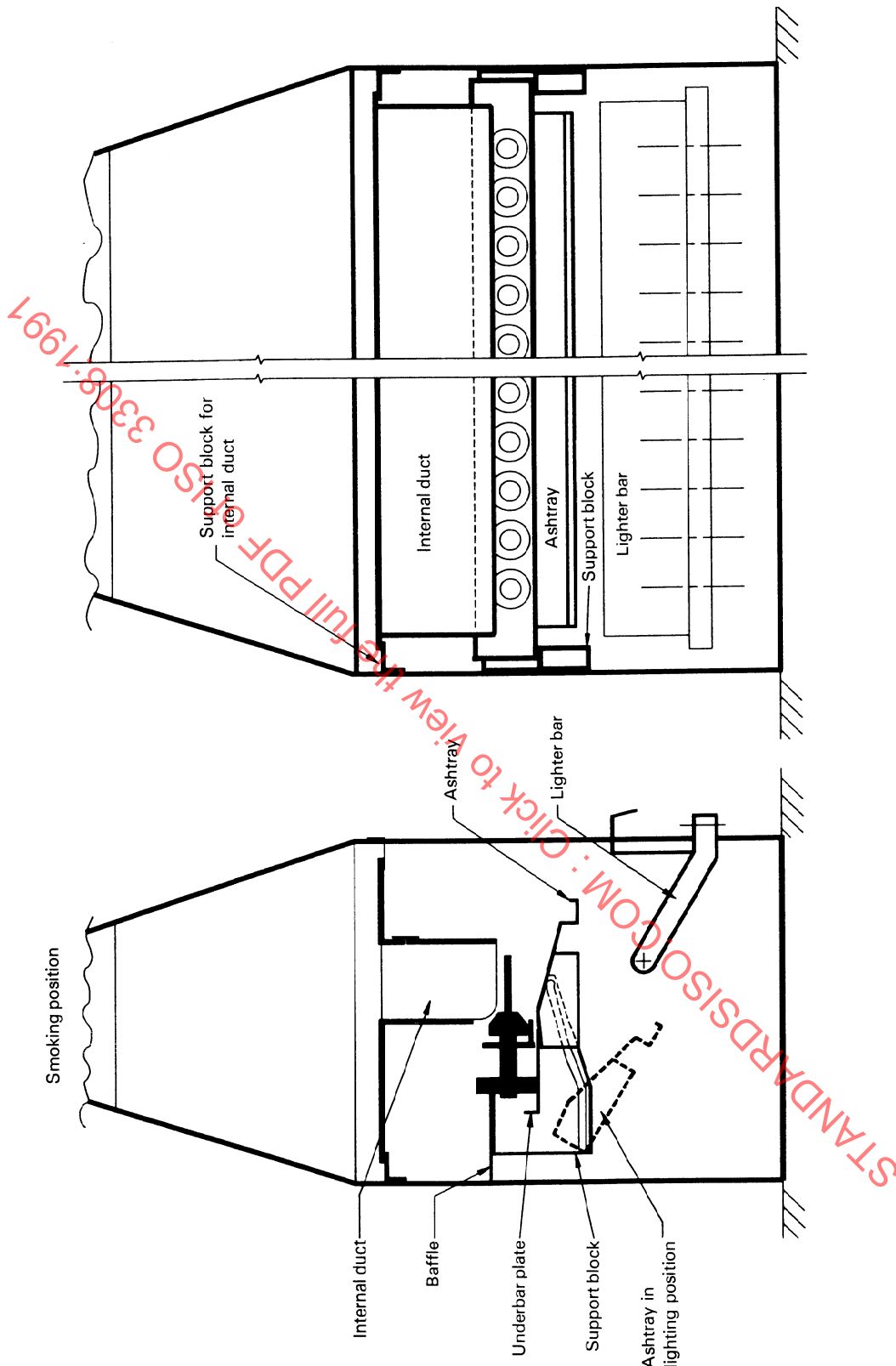


Figure A.4 — Schematic views of 20-channel linear machine

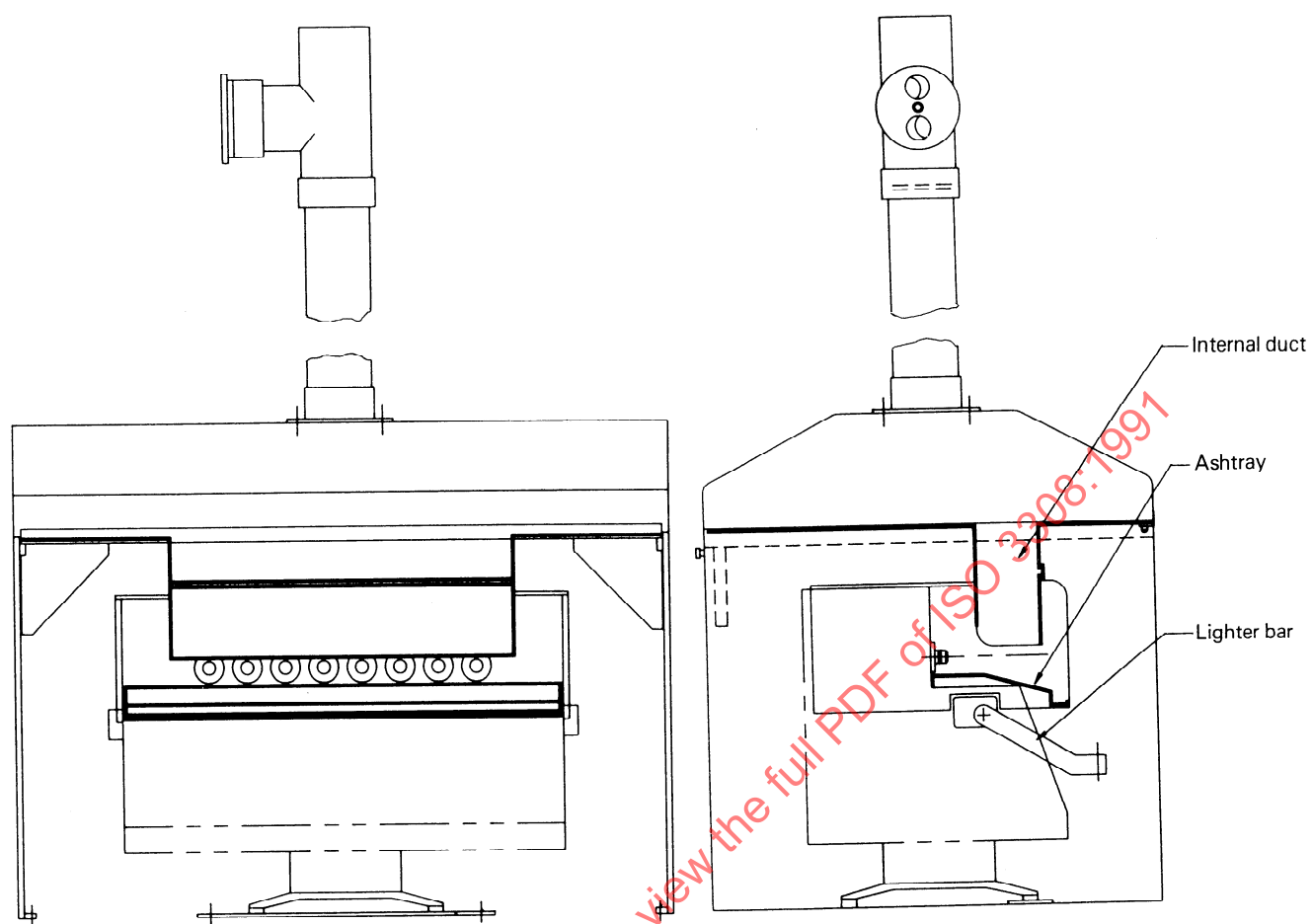


Figure A.5 — Schematic views of 8-channel linear machine — General view without carbon monoxide collection