INTERNATIONAL STANDARD ISO 3308

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Tobacco and tobacco products — Routine analytical cigarette-smoking machine — Definitions, standard conditions and auxiliary equipment

Tabac et produits du tabac — Machine à fumer analytique de routine pour cigarettes — Définitions, conditions normalisées et équipement auxiliaire

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3308 was developed by Technical Committee ISO/TC 126, *Tobacco and tobacco products*, and was circulated to the member bodies in December 1976.

It has been approved by the member bodies of the following countries :

Belgium	Iran	Spain
Brazil	Italy	Sweden
Bulgaria	Mexico	Switzerland
Czechoslovakia	Netherlands	Turkey
France	Poland	United Kingdom
Germany	Romania	U.S.S.R.
India	South Africa, Rep. of	Yugoslavia

The member body of the following country expressed disapproval of the document on technical grounds :

Japan

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Tobacco and tobacco products — Routine analytical cigarette-smoking machine — Definitions, standard conditions and auxiliary equipment

0 INTRODUCTION

This International Standard includes the requirements found necessary in the light of knowledge and experience gained with analytical smoking machines.

Other items will also need to be specified for the preparation of a complete International Standard on mechanical smoking : methods of test for smoking machines, cigarette sampling, method of smoking, expression of results.

From work on these items amendment of the text set out below may prove necessary.

1 SCOPE AND FIELD OF APPLICATION

This International Standard :

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

— specifies requirements for a routine analytical smoking machine which enables the standard conditions to be complied with and for the auxiliary equipment.

NOTE — Annex A describes, by way of example, the special characteristics of a typical smoking machine incorporating a piston type of puffing mechanism.

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

2 REFERENCE

ISO . . ., *Analytical cigarette-smoking machines — Methods of test.*[1)]

3 DEFINITIONS

3.1 draw resistance : The difference in static pressure between the two ends of a cigarette or between two points in a smoking machine between which a current of air passes at a constant flow rate of 17,5 ml/s.

3.2 puff duration : The interval of time during which a difference in pressure is applied between the two ends of a cigarette.

3.3 puff volume : The volume leaving the butt end of the cigarette during the interval of time during which there is a pressure difference between the two ends of the cigarette.

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

3.5 puff profile : The flow measured directely behind the butt end of the cigarette, and depicted graphically as a function of time.

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

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

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

3.9 total dead volume : The volume which exists between the butt end of the cigarette and the suction source.

3.10 butt length : The length of cigarette remaining after smoking the cigarette at the moment when smoking is stopped.

3.11 mainstream smoke : The smoke comprising all the substances leaving the butt end of the cigarette during smoking.

3.12 smoulder stream smoke : The smoke comprising all the substances which leave the butt end of the cigarette during the intervals of time between puffs.

3.13 sidestream smoke : The smoke comprising all the substances which leave the cigarette during smoking other than from the butt end.

1) In preparation.

3.14 cigarette holder : The device for holding the butt end of the cigarette during the smoking procedure.

3.15 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.

3.16 ventilated room : A room having a forced circulation of air.

3.17 non-ventilated room : A room in which the speed of the air current in the vicinity of the cigarettes during smoking is not greater than that of a normal convection current.

3.18 cigarette position : The position of the 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 the cigarette is inserted into a cigarette holder in an analytical smoking machine.

4 STANDARD CONDITIONS

4.1 Machine draw resistance

The whole flow path between the butt end of the cigarette and the suction source shall offer the least possible draw resistance and the pressure drop shall not exceed 300 Pa (3 mbar).

4.2 Puff duration

The standard puff duration shall be 2,0 s with a standard deviation of $\sigma = 0{,}05$ s for individual puffs.

4.3 Puff volume

The standard puff volume shall be 35 ml, measured on an unlit cigarette, with a standard deviation for individual puffs of $\sigma = 0{,}25$ ml. In one puff duration not less than 95 % of the puff volume shall leave the butt end of the cigarette.

4.4 Puff frequency

The standard puff frequency shall be one puff every 60 s with a standard deviation for this time of $\sigma = 0{,}5$ s.

4.5 Puff profile

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 puffing. The increasing and decreasing parts of the profile shall not have more than one point of inflection each. The maximum flow rate shall lie between 25 ml/s and 30 ml/s. (See annex B.) The curve may be amputated up to 0,02 s from the start. (See A.2.2.)

NOTE – A description of an example of a puffing mechanism using a piston pump to obtain the puff profile is given in annex A.

4.6 Restricted smoking

An analytical smoking machine shall be a restricted smoker.

4.7 Free smoking

Free smoking is not covered by this International Standard.

4.8 Puff number

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

4.9 Total dead volume

The total dead volume shall be as small as possible and shall not exceed 100 ml.

4.10 Butt length

The standard butt length is 23 mm except for cigarettes with a filter longer than 15 mm which shall be smoked to the greater of the following two lengths :

– length of filter + 8 mm, or

– length of filter overwrap + 3 mm.

NOTE – The "filter overwrap" is the external material which joins the tobacco rod to the filter tip.

4.11 Mainstream smoke

It is not possible to standardize a condition.

4.12 Smoulder stream smoke

It is not possible to standardize a condition.

4.13 Sidestream smoke

It is not possible to standardize a condition.

4.14 Cigarette holders

The standard cigarette holder shall cover 9 mm, with a standard deviation of $\sigma = 0{,}5$ mm, from the butt end of the cigarette and shall be impermeable to smoke components and to air. The standard cigarette holder shall ensure that the leakage between the cigarette and the cigarette holder is not greater than 0,5 % of the puff volume. The draw resistance of the unlit cigarette shall not significantly increase when it is held in the cigarette holder.

NOTE – Exact figures for the maximum allowable increase of draw resistance of the unlit cigarette when it is held in the cigarette holder will be given in ISO . . .

4.15 Ambient conditions

The difference between the mean puff number of cigarettes smoked in a ventilated room and the mean puff number of cigarettes smoked in a non-ventilated room shall not exceed 3 % of the mean puff number obtained in the non-ventilated room (with a confidence level of 95 %).

In a non-ventilated room, cigarettes shall not be smoked in their own sidestream smoke.

4.16 Cigarette position

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

5 SPECIFICATION FOR A ROUTINE ANALYTICAL SMOKING MACHINE

The smoking machine shall comply with the standard conditions (see 4.1 to 4.16) 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 by applying a difference in pressure between the front (lit) end and the butt end of the cigarette.

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 (see 3.6).

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, 4.3 and 4.4) for prolonged periods.

5.2.2 The machine shall be capable of sufficient compensation.

NOTE — Compensation is the ability to maintain consistent puff volumes and puff profiles when the pressure drop of the cigarettes changes.

When the machine has initially been set to give the standard puff volume of 35 ml without draw resistance, a reduction of no more than 1,5 ml shall be observed when the machine is tested with a draw resistance of 3 000 Pa (30 mbar) and a flow rate of 17,5 ml/s.

5.2.3 The connecting piping between the filter holder (6.1) and the suction source shall offer the least possible resistance to flow. The draw resistance of the total flow path between the butt end of the cigarette and the suction source shall not exceed 300 Pa (3 mbar) before smoking (see 4.1).

5.2.4 The total dead volume shall be as small as possible (see 4.9).

5.3 Cigarette holders and smoke traps

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

5.3.1 The machine shall be equipped to enable the smoke to be trapped on glass fibre filter discs (6.2) held in the filter holders (6.1).

5.3.2 The cigarettes to be smoked shall be attached to the filter holders (6.1) by standard cigarette holders (see 4.14).

5.3.3 The smoking ports to which suction is applied shall be positioned on the machine. The smoking ports shall be designed to hold the filter holders (6.1) so that the cigarettes are presented in the standard position (see 4.16).

The machine shall be designed to prevent losses of smoke constituents between the butt end of the cigarette and the filter holder.

The distance between the butt end of the cigarette and the filter shall be as small as possible but not less than 5 mm.

5.3.4 The smoking ports shall be arranged so that the sidestream smoke does not affect cigarettes smoked in adjacent ports (see 4.16). The distance between the centres of adjacent burning zones shall be at least 50 mm.

5.3.5 Each port shall have its own puff termination device linked to the puff counter (see 5.5); the device may be either :

a) a micro-switch activated by the burning through of a cotton thread; or

b) an infra-red detector.

5.3.6 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 (see 4.10).

5.3.7 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 ambient air flow shall be such that sidestream smoke can be effectively removed without changing the rate of free combustion of the cigarettes during the intervals of time between puffs (see 4.15).

It is recommended that the linear air speed across the cigarettes should be adjustable to between 35 mm/s and 40 mm/s.

5.5 Puff counting

Each port shall have its own puff counter capable of counting to the nearest 0,1 puff (see 4.8).

5.6 Ignition

Electrical, gas flame or alcohol flame ignition may be used.

Electrical ignition is recommended as it has proved satisfactory in practice. If used, electrical lighters shall be hot enough to light the cigarettes at the first attempt. Each lighter should incorporate a locking device to lock it in position once set (i.e. 1 mm from the end of the cigarette).

If gas or alcohol flame ignition is used, the flame shall be adjusted so that it does not touch the end of the cigarette before the lighting puff.

6 AUXILIARY EQUIPMENT

Auxiliary equipment shall include the following :

6.1 A filter holder, made of an airtight and chemically inert material, preferably transparent.

6.2 A filter disc, of glass fibre material, 1 to 2 mm thick and with a diameter of at least 44 mm. The rough filter surface shall face the oncoming smoke.

The filter material shall have the following characteristics :

It 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 draw resistance of the filter assembly shall not exceed 900 Pa (9 mbar). The content of polyacrylate binder shall not exceed 5 % (*m/m*).

The filter assembly shall be capable of quantitatively retaining all the mainstream smoke produced by the cigarettes without loss of crude smoke condensate. In addition, the filter assembly shall be chosen so that the increase in the draw resistance of the assembly does not exceed 250 Pa (2,5 mbar), at a flow rate of 17,5 ml/s when measured after the smoking.

6.3 Cigarette holders, capable of holding the butt end of the cigarette during smoking. The standard conditions relative to the length of butt covered by this device, the influence of this device on the draw resistance of the cigarette and the airtightness of the seal are given in 4.14. It shall not induce sweating.

A vacuum holder or a labyrinth seal is recommended for attaching cigarettes.

6.4 Devices 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.

ANNEX A

DESCRIPTION OF THE PUFFING MECHANISM OF A PISTON TYPE SMOKING MACHINE

The following description defines an example of use of the piston principle which is a recognized and proved system, but it is not intended to preclude or restrict the future development of smoking machines.

A.1 DESCRIPTION OF THE PUFFING MECHANISM

The piston may be :

a) either a conventional piston and crank shaft with connecting rod and small end, P [see figure 1 a)]; or

b) the well-established arrangement in which the cylinder is pivoted at H and the piston is connected to the crank shaft [see figure 1 b)].

Alternative b) gives a non-symmetrical profile (see figure 2) when measured without a cigarette but attains symmetry under smoking conditions. The crankshaft describes a circular path and is driven intermittently by an electric motor with variable speed control.

A.2 SPECIAL CONSIDERATIONS

A.2.1 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. This volume shall be measured immediately at the cylinder inlet.

A.2.2 Puff volume

The puff volume is adjusted to 98 ± 1 % of the total swept volume so as to eliminate the "skirt" or "tails" of the puff. To achieve this in relation to the piston movement, the beginning of the puff needs to be retarded and the end advanced, adjustments that can best be achieved by a cam and microswitch assembly or by similar devices.

A.3 DESIGN CONSIDERATIONS OF PUFFING MECHANISM

It would appear that specifications of A, r and h are the most important design considerations. Since $2\,A\,r$ equals puff volume, once A is chosen for reasons of convenience or availability of pistons, r is automatically fixed and h determines the shape of the puff. If reasons of symmetry are paramount, h should be as large as possible and not less than $10\,r$. Therefore, in the manufacture of a piston type of smoking machine, the following should apply :

A.3.1 The speed of rotation of the shaft shall be constant during puffing, shall be fully adjustable and shall have fine control.

A.3.2 The cylinder shall have a bore of 28 ± 1 mm and a stroke that can be varied up to 80 mm. This covers the puff volume, range 0 to approximately 50 ml and gives a bore/stroke ratio of 0,5 at the 35 ml level. This specification may be considered too rigid but it is one that works very well in practice and gives the recommended puff characteristics.

A.3.3 It is desirable that pistons and cylinders should be completely interchangeable.

A.3.4 The distance h should be greater than $10\,r$.

A.3.5 The piping between the filter holder and the cylinder should offer the least possible draw resistance (see 5.2.3).

A.3.6 The dead volume between the cylinder and the filter holder shall be as small as practicable. The total dead volume, including the filter holder, the connecting tubing and the cylinder when the piston is at top dead centre shall not exceed 100 ml (see 4.9).

A.3.7 In order to ensure that the machine performs according to the specification, incorporation of a mechanism may be necessary to start or stop the piston at a definite point.

A.3.8 The puffing mechanism shall have fine control of puff to the nearest 0,1 ml for each port. The suggested range is 2 ml.

A.4 TIMING CYCLE OF SOLENOID VALVE

Each port is fitted with a three-way solenoid valve for the purpose of applying suction to the cigarette.

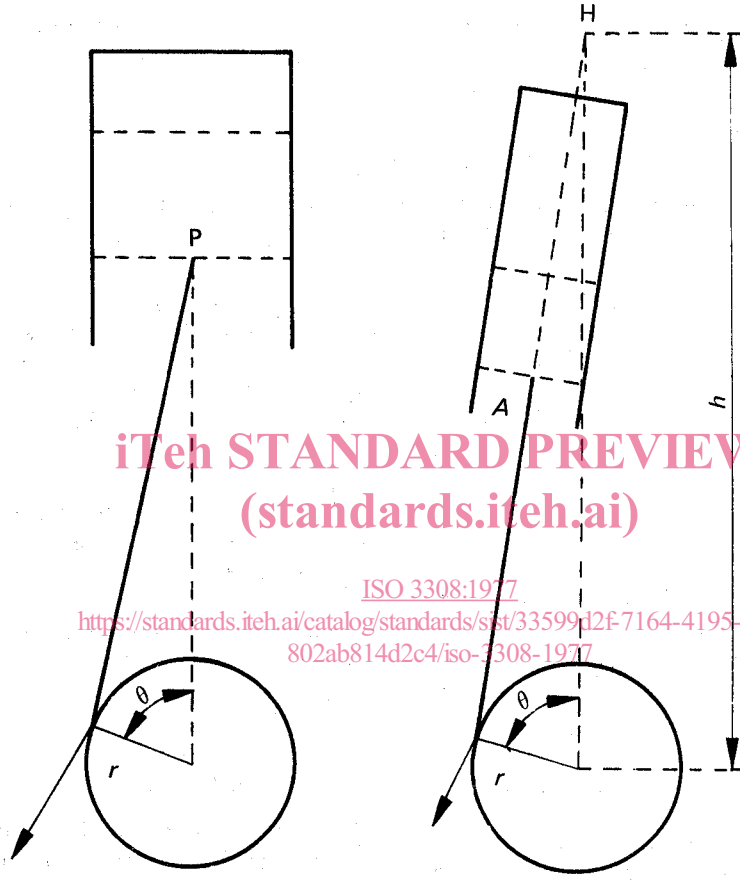
A puffing cycle consists of the following sequence of operations, described below for a piston type smoking machine. Other suitable mechanisms should nevertheless reproduce exactly the same conditions.

a) With the piston at top dead centre i.e. when the angle θ in figures 1 a) and 1 b) is 0°, the path from piston to cigarette is closed, the path between the piston and the by-pass to atmosphere is open.

b) When the angle θ is between 5° and 10° past top dead centre (to remove leading tail) the path between the piston and the cigarette is open, the path between the piston and the by-pass to the atmosphere is closed.

c) When the angle θ is between 5° and 10° before bottom dead centre (to remove trailing tail) the path between the piston and the cigarette is closed, the path between the piston and the by-pass to the atmosphere is open.

The vapour phase is then automatically vented to atmosphere as the piston returns to top dead centre.



A = area of cross-section
r = radius of crank
h = distance between crank and pivot.

a) b)

FIGURE 1 — **Puffing mechanism**

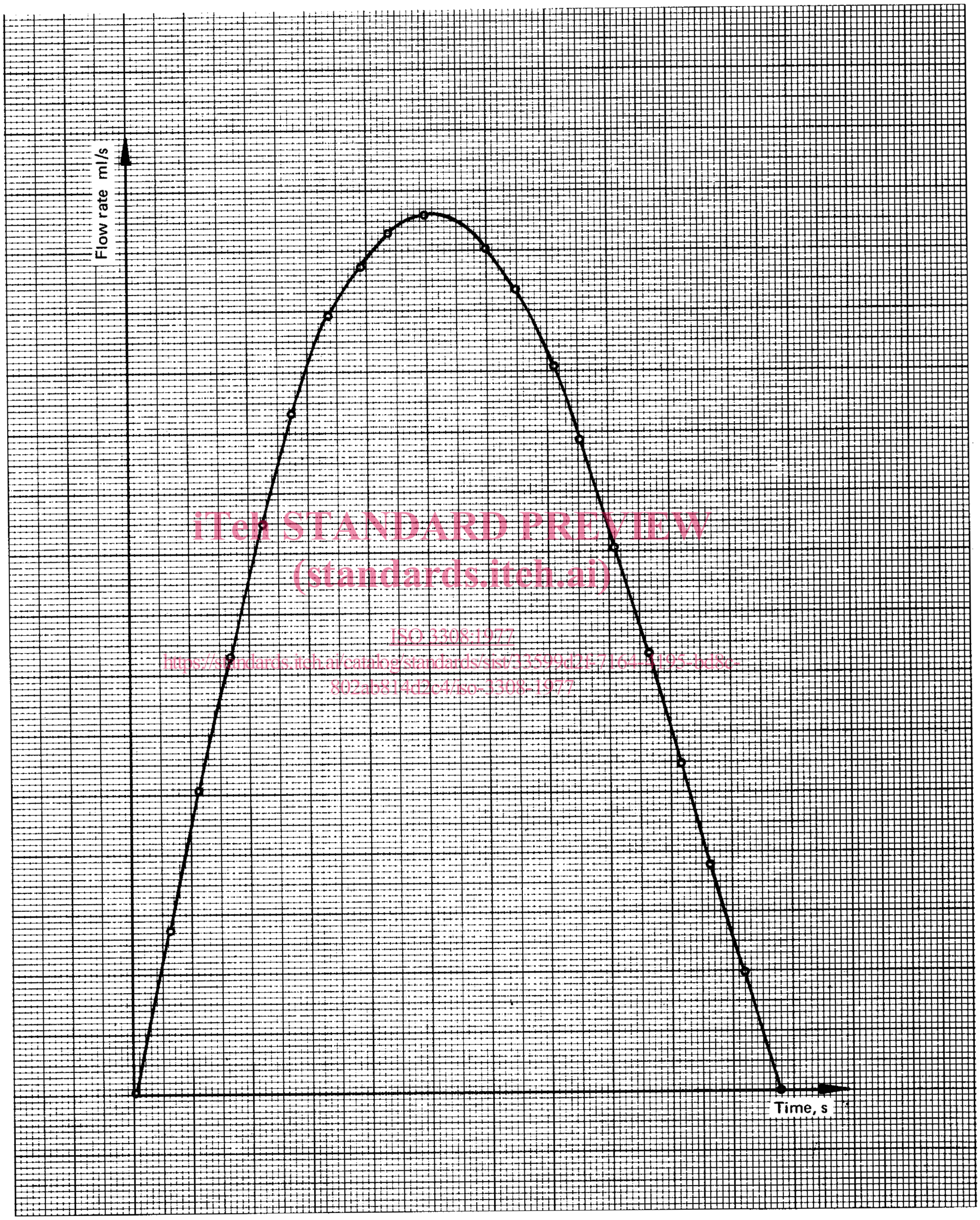


FIGURE 2 — **Typical puff profile without cigarette**