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International Standard



3308

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

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

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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.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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

This second edition cancels and replaces the first edition (ISO 3308-1977), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

# Cigarettes — Routine analytical cigarette-smoking machine — Definitions and standard conditions

## 0 Introduction

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

Other aspects relevant to an International Standard on mechanical smoking include methods of test for smoking machines, cigarette sampling and expression of results. From work on these aspects, amendment of the clauses set out below may prove necessary in a future revision.

## 1 Scope and field of application

This International Standard

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

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

## 3 Definitions

**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 — 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 a difference in pressure is applied between the two ends of a cigarette.

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

**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 difference in pressure applied between the two ends of the cigarette.

**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 source.

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

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

**3.15 port :** The aperture of the puffing mechanism through which a puff is drawn and to which is attached a smoke trap and/or a cigarette.

**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.

## 4 Standard conditions

### 4.1 Machine pressure drop

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

### 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 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.

### 4.10 Cigarette holders

The standard cigarette holder shall cover 9 mm, with a standard deviation of  $\sigma = 0,5$  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 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.

### 4.11 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 the routine analytical smoking machine

The smoking machine shall comply with the standard conditions (see 4.1 to 4.11) 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 (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, 4.3 and 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 the standard puff volume of 35 ml without pressure drop, a reduction of no more than 1,5 ml shall be observed when the machine is tested with a pressure drop of 3 000 Pa (30 mbar) and a flow rate of 17,5 ml/s.

**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 (3 mbar) 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, the influence of this device on the draw resistance of the cigarette and the airtightness of the seal are given in 4.10. The holders shall not induce sweating.

A vacuum holder or a labyrinth seal is recommended 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. 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 4.10).

**5.3.4** The smoking ports shall be designed to hold the smoke traps or the cigarette holders so that the cigarettes are presented in the standard position (see 4.11).

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

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

**5.3.5** The smoking ports shall be arranged so that the sidestream smoke does not affect cigarettes smoked in adjacent ports (see 4.11). The distance between the centres of adjacent burning zones shall be at least 50 mm.

**5.3.6** Each channel shall have a puff termination device linked to a butt length (mark) sensor and the puff counter. When activated by the sensor the device shall prevent any further difference in pressure being applied between the two ends of the cigarette.

The sensor may be either :

- a) a micro-switch activated by the burning through of a cotton thread; or
- b) an infra-red detector.

**5.3.7** 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 4.9).

**5.3.8** 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 linear air speeds across the cigarettes shall be adjustable to between 35 mm/s and 40 mm/s 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.

## 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 flame 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.

## Annex A

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

(This annex does not form an integral part of the standard.)

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 Principle of puffing mechanism

The mechanism may be either :

- a) a conventional piston and crankshaft with connecting rod and small end, P [see figure 1a)]; or
- b) the well-established arrangement in which the cylinder is pivoted at H and the piston is connected to the crankshaft [see figure 1b)].

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 is measured immediately at the cylinder inlet.

##### A.2.2 Puff volume

The puff volume is adjusted to  $98 \pm 1$  % 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 micro-switch assembly linked to a three-way solenoid valve fitted to each piston.

#### A.3 Design considerations of puffing mechanism

It would appear that specifications of  $A$ ,  $r$  and  $h$  are the most important design considerations. Since  $2Ar$  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  $10r$ . 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  $28 \pm 1$  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 be completely interchangeable.

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

**A.3.5** The piping between the smoke trap and the cylinder should offer the least possible pressure drop (see 5.2.3).

**A.3.6** In order to ensure that the machine performs according to the specification, incorporation of a mechanism to start or stop the piston at a definite point may be necessary.

**A.3.7** The puffing mechanism should have fine control of puff to the nearest 0,1 ml for each channel. The suggested range is 2 ml.

#### **A.4 Timing cycle of solenoid valve**

A puffing cycle consists of the following sequence of operations, described below for a piston type of smoking machine complying with A.2.2. Other suitable mechanisms should nevertheless reproduce exactly the same conditions.

- a) With the piston at top dead centre [i.e. when the angle  $\theta$  in figures 1a) and 1b) is  $0^\circ$ ], the piston-to-cigarette path is closed and the piston-to-bypass path (to atmosphere) is open.
- b) The opening of the piston-to-cigarette path and the closing of the piston-to-bypass path is delayed for an angle  $\theta$  of up to  $5^\circ$  past top dead centre (to remove the leading tail).
- c) When the angle  $\theta$  is less than  $10^\circ$  before bottom dead centre the piston-to-cigarette path is closed (to remove the trailing tail) and the piston-to-bypass path is opened.

The vapour phase is then automatically vented to atmosphere (unless a collecting device is fitted) as the piston returns to top dead centre.

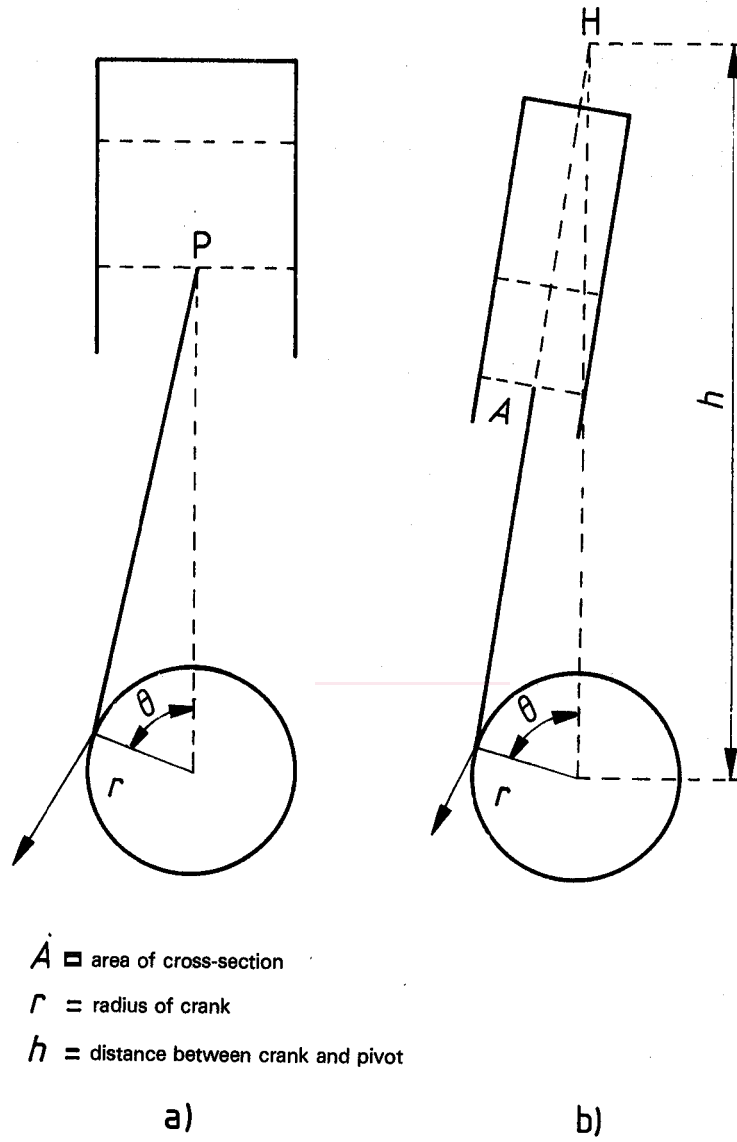


Figure 1 — Puffing mechanism



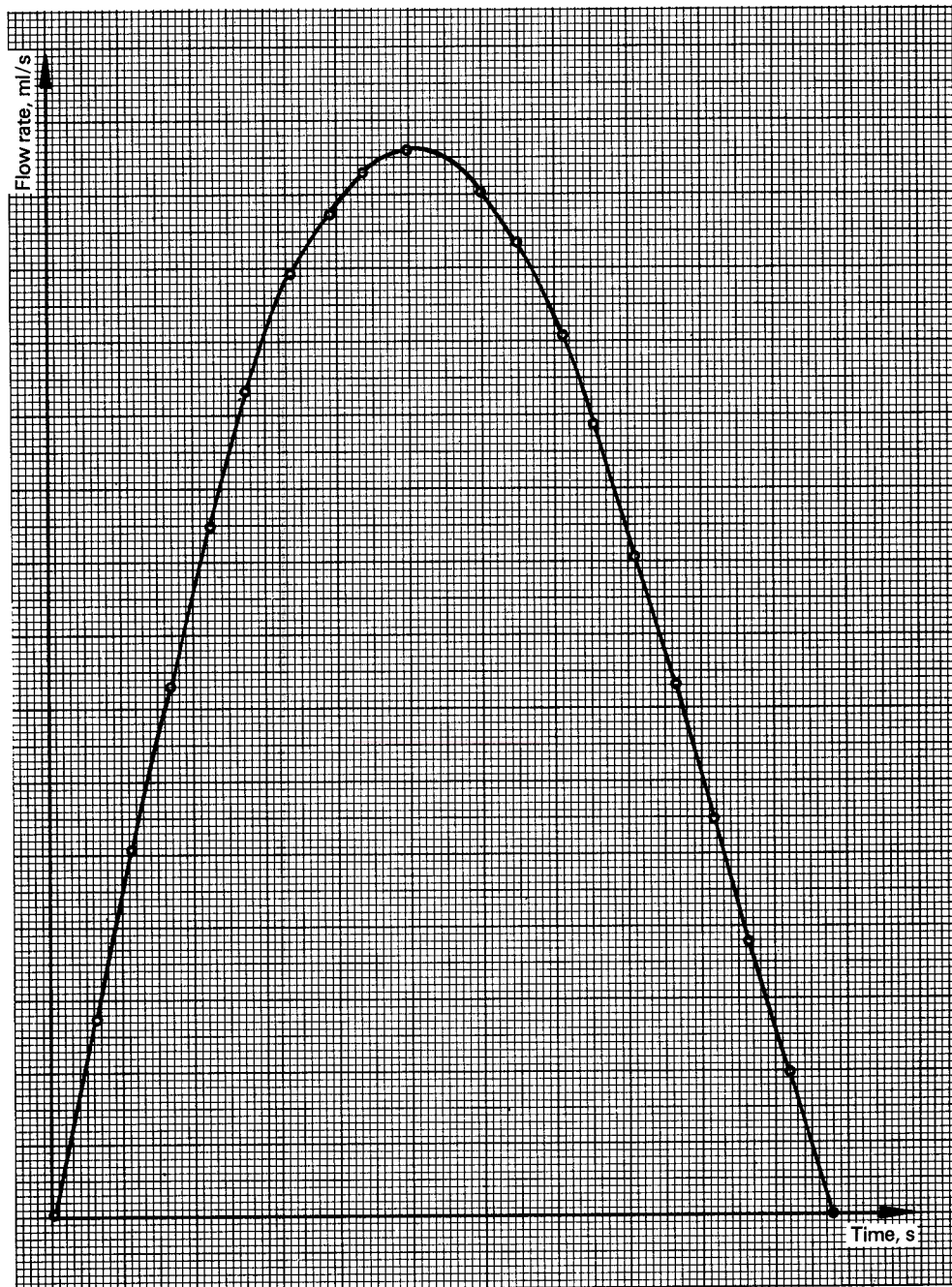


Figure 2 — Typical puff profile without cigarette

## Annex B

### Diagrammatic representation of a puff profile

(This annex does not form an integral part of the standard.)

**B.1** To illustrate certain definitions and certain standard conditions, the puff profile may be described as follows (see figure 3) :

At time  $t = 0$ , a pressure difference may be applied to the cigarette. The flow rate  $\Phi$  at the butt end of the cigarette varies to give a bell-shaped puff profile. The maximum flow rate  $\Phi_m$  is reached at time  $t_m$ . The flow rate then decreases during the puff duration to reach the value  $\Phi_d$  at time  $t_d$  when the puffing source ceases to apply a pressure difference.

Finally, the flow rate decreases slowly to 0, a value reached at time  $t_e$  (end of puff).

**B.2** The standard puff profile shall have its maximum so that

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

at time  $t_m$  so that

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

The standard puff duration shall be  $t_d = 2,0 \text{ s}$  and the time  $t_e$  shall be limited by the standard puff frequency to  $t_e = 60 \text{ s}$ .

The puff volume  $V$  shall be calculated on the basis of the shaded area in figure 3, 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 standard conditions shall be the following :

$$V = 35 \text{ ml}$$

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

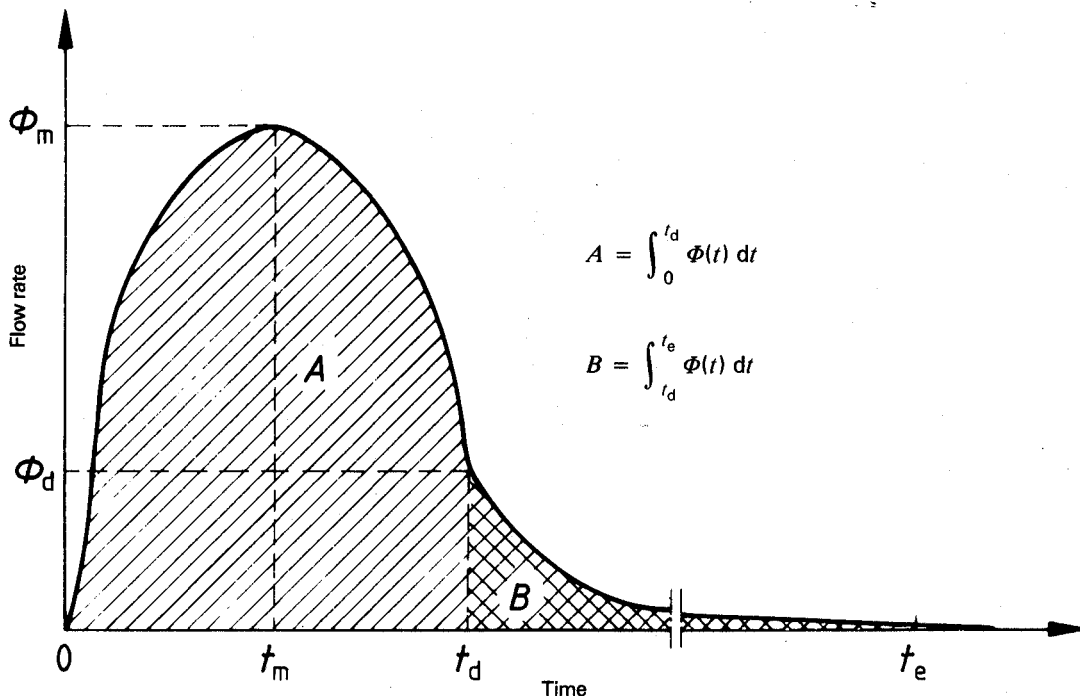


Figure 3 — Diagrammatic representation of a puff profile with cigarette