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ICS

English Version

## Candles - Test method for measuring the soot index

Kerzen - Prüfverfahren zur Messung des Rußindex

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COMITÉ EUROPÉEN DE NORMALISATION  
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## Foreword

This document (prEN 15426:2005) has been prepared by Technical Committee CEN/BT/TF 164 “Candle safety”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

## Introduction

This document describes a method which will facilitate simple evaluation of the sooting behaviour of candles. The soot index obtained by this procedure may be considered as characteristic of the sooting behaviour of the type of candle tested.

The soot which is emitted from a candle is collected on a glass plate throughout a defined burning period. Afterwards the attenuation of light intensity caused by soot precipitation is quantified in a measuring chamber.

The advantages of the method are, that it is uncomplicated and inexpensive to use and that the results can be quickly and simply evaluated.

In addition to the evaluation of soot being emitted by a candle whilst burning, it comprises the determination of the hourly fuel consumption.

This method helps to ensure a reasonable degree of safety for normal use, thereby improving personal safety and reducing fires, deaths and injuries.

## 1 Scope

This document specifies requirements regarding the method for evaluation of the sooting behaviour of burning candles. This method is suitable for all candles designated to be burnt indoors. The method is not suitable for multi-wick candles.

## 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.

prEN aaa (CSH99017), *Candles – Specification for fire safety*.

## 3 Terms and definitions

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

### 3.1

#### **base material**

Intended fuel source for candle flame

### 3.2

#### **burning cycle**

Total length of time the candle is burned during one test cycle, including pause

### 3.3

#### **burning period**

Total time the candle is burned over the duration of the test (sum of the burning cycles and initial burning cycles)

### 3.4

#### **candle**

One or more combustible wicks supported by a material that constitutes a fuel which is solid, semisolid or quasi-rigid at room temperature (20-27°C). It can also contain additives, which are used for colour, odour, stability, or to modify the burning characteristics; the combined function of which is to sustain a light-producing flame. Including candles with decorative elements

### 3.5

#### **container candle**

Candle which is produced in and will be burned up in a container

### 3.6

#### **decorative elements**

Decoration attached to or contained within the candle

### 3.7

#### **filled container candle**

Candle, which is produced in and will be burned up in a container

### 3.8

#### **gel candle**

Candle where the primary fuel is a liquid, such as a mineral oil, terpene type chemicals, or modified hydrocarbons that are not mineral oil based, which may or may not contain organic functional groups; it also

contains a chemical agent to increase the viscosity (thicken) to a point where the candle has a quasi-rigid property.

**3.9  
molten fuel pool**

Portion of the wax or fuel pool of a candle that is in the liquid form when the candle is burning

**3.10  
rim of the candle**

Rim that is formed by non-consumed base material above the liquid burning bowl

**3.11  
self made candle**

Candle made by the consumer themselves, of burning materials manufactured for the purpose of being burned

**3.12  
soot**

Soot is made up of solid, hydrocarbon enriched particles, which come into existence when the burning material in the flame is incompletely burned and which are subsequently released into the atmosphere

**3.13  
soot index**

Index number for the evaluation of the sooting behaviour of candles

**3.14  
tea light candle**

Cylindrical filled candle which is burned up in a container, e.g. made from metal, glass or plastic, which may be suitable to keep vessels containing coffee, tea or other liquids warm, by using a warming stove. The mean of a tea light is  $(38 \pm 1)$  mm, its height max 17 mm.

**3.15  
total burning time**

Total time the candle is burning to burn down

**3.16  
visible emissions**

Emissions that can be seen once collected on a substrate

**3.17  
wax**

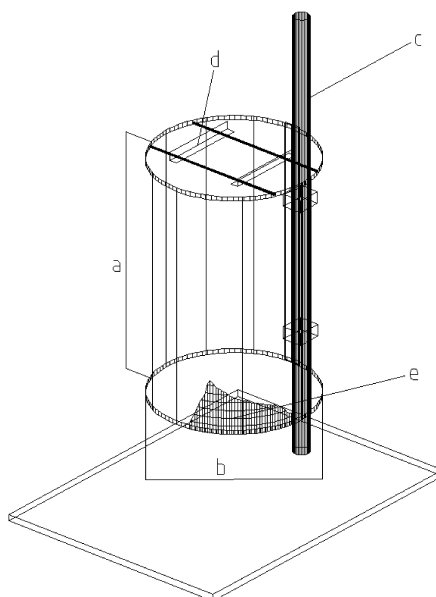
Crystalline, plastic solid or semi-solid material at 25°C consisting of a mixture of hydrocarbons and/or hydrocarbon derivatives that, typically at temperatures equal to or greater than 40°C, melts and becomes a low viscosity liquid. Waxes may be of mineral (particularly petroleum), vegetable, animal (including insect), or synthetic origin

**3.18  
wick**

Object that delivers fuel to a flame through the process of capillary action

## **4 Test equipment and Apparatus**

**4.1 A wire mesh cylinder**, fixed to a stand of which the height can be adjusted, with a fixture for a glass plate (see Figure 1). The cylinder has a minimum height of 300 mm and consists of wire mesh with a permeability of 60 %.

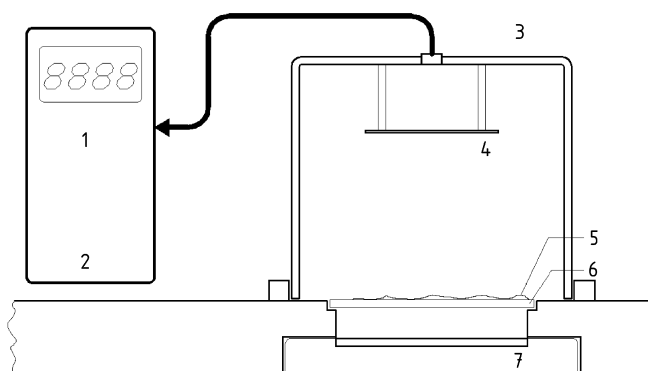


- a Max. height,  $h = 300$  mm
- b Diameter, Type 1:  $d = 230$  mm; Type 2:  $d = 300$  mm
- c Stand
- d Glass plate
- e Wire mesh

**Figure 1 — Wire mesh cylinder**

**4.2 Measurement unit** consisting of an indication instrument and a measuring chamber. The measuring chamber consists of the light source, fixture for the glass plate, a cover with light reflecting interior coating with a photodiode integrated in it, which is connected with the indication instrument (see Figure 2).

**NOTE** First operation and calibration of the measurement unit refer to Annex 1.



**Key**

- 1 Detector current
- 2 Photometer
- 3 Photo detector
- 4 Shutter
- 5 Soot precipitation
- 6 Glass plate
- 7 Light plate

**Figure 2 — Measurement unit**

**4.3 Heat resistant glass plates** of the same type as soot absorbers, (100 mm x 100 mm), with a thickness of (3,5 – 4,5) mm. Each glass plate is to be marked in such a way that it can be easily identified and the marking does not affect the measurement results. The light absorption of these glass plates shall not exceed 25 % (see equation 1).  $E_v$  is the individually measured light intensity.

$$1 - \frac{E_{v, \text{glass plate}}}{E_{v, \text{empty measuring chamber}}} \times 100 \leq 25 \quad (1)$$

Where

$E_{v, \text{glass plate}}$  Light intensity of the glass plate, in cd/m<sup>2</sup>  
 $E_{v, \text{empty measuring chamber}}$  Light intensity of the empty measuring chamber, in cd/m<sup>2</sup>

- 4.4 Stop watch**
- 4.5 Scales with 0.1 g accuracy**
- 4.6 Ruler**
- 4.7 Standard, fat dissolving detergent**
- 4.8 Lint free paper towels**
- 4.9 Pair of scissors**
- 4.10 Suitable candle holder**
- 4.11 Stand for height adjustment**
- 4.12 Glass platform**, max. 70 mm in diameter for tea lights

## 5 Sampling

The test will be carried out on finished candles, intended to be supplied commercially. The temperature of the sample shall be (20 ± 5) °C before the test is started

For each type of candle to be tested a minimum of 3 samples must be tested. The candle and/or container/jar shall have no defects. Conformity to the requirement shall be verified by visual examination. If any defects occur do not continue the test. Record whether any defects are verified or not.

## 6 Sample preparation

Prepare the sample for use according to the manufacturer's instructions, if any given, e.g. trim the wick. Measure the length from the bottom to the tip of the wax body, diameter and weight of the sample and record in mm and g, respectively.

## 7 General test conditions

The room temperature at which the burning test is to take place shall be (20 ± 5) °C and protected from draughts as far as possible. If during the test the temperature or humidity is outside the range, the maximum and/or minimum temperature or humidity shall be recorded in the test report.

## 8 Test Procedure

### 8.1 General

In the case of candle designs not catered for in the test procedures, the test should be carried out as far as possible as described and deviations from the test procedure recorded in the test report.

NOTE If sooting becomes excessive the measuring may be stopped early.

### 8.2 Test preparation

The wire mesh cylinder type shall be selected according to table 1

**Table 1 — Apparatus**

	Apparatus
Tea lights	Wire mesh cylinder Type 1
Candles	
$\varnothing \leq 70$ mm	Wire mesh cylinder Type 1
$70$ mm $< \varnothing \leq 150$ mm	Wire mesh cylinder Type 2

Set up the apparatus on an even surface and select a heat resistant surface or base for the candle to stand on.

### 8.3 Burning test

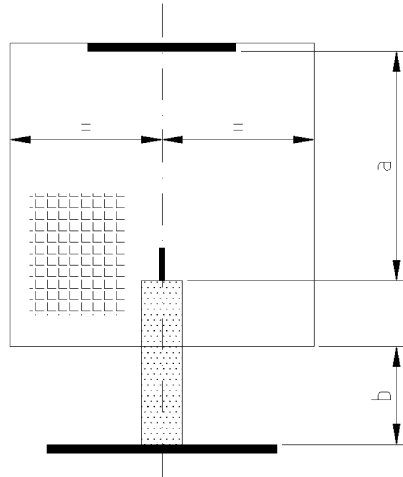
Position the wire mesh cylinder centrally above the sample. Adjust the distance (a) between the top of the solid base material and the glass plate to 180 mm (see figure 3). If the distance is more than 240 mm adjust accordingly.

A gap (b) of at least 50 mm should remain between the bottom of the cylinder and the surface the candle is positioned on. If the gap is smaller the candle shall be placed on a stand to put it in a higher position. The diameter of this stand shall not exceed 1/3 of the diameter of the wire mesh cylinder, as the air exchange within the cylinder would otherwise be hindered (see figure 3).

Position the wick correctly and light the candle. Place a clean glass plate in the holder of the wire mesh cylinder. The burning cycles shall be chosen for different candle types according to table 2. When the burning cycle ends, remove the wire mesh cylinder or glass plate before extinguishing so that smoke from the afterglow does not affect the test result<sup>1)</sup>. Record the start and the end times of the burning cycles, pauses and initial burning cycles.

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1) The 2<sup>nd</sup> and 3<sup>rd</sup> burning cycles are carried out without extinguishing the candle after the initial burning cycle.



**Key**

- a (180 -0 + 40) mm
- b min. 50 mm

**Figure 3 — How to set up the equipment**

Check the distance between the surface of the molten fuel pool of the candle and glass plate prior to each test period and adjust to 180 mm if necessary. The initial burning period takes place without the wire mesh cylinder or glass plate. The same procedure is followed for tea lights, the only deviation being that they are placed on a glass platform max., 70mm in diameter, to ensure a distance of  $(50 \pm 5)$  mm between the rim of the cup/container and the glass plate.

When measurement is complete, remove the wire mesh cylinder or glass plate, extinguish the candle and allow the glass plate to cool down for at least 15 min. Measure the weight of the candle after burning and record the result.

**Table 2 — Sooting measurement period**

Type of candle	Burning cycle 1	Pause	Initial burning cycle 2	Burning cycle 2	Pause	Initial burning cycle 3	Burning cycle 3
Weight below 40 g	Continuous burning to residual height of 10 mm						
Tea lights	Continuous burning until self extinguishing						
Weight above 40 g and diameter less than 70 mm	240 min	> 60 min	5 min	240 min or continuous burning to residual height of 10 mm			
Weight above 40 g and diameter equal or over 70 mm	240 min	> 60 min	5 min	240 min	> 60 min	5 min	240 min

## 9 Measuring of the emission on the glass plate

Calibrate as in A.2.

Place the sooted glass plate, soot side up, within the holder on the light source and close the cover. If necessary, adjust the measuring range, determine the light intensity ( $E_{v, \text{sooted glass plate}}$ ) and record the result.

Clean the glass plate with detergent (4.7) and water and, dry the glass plate (4.3) afterwards using lint free paper towels (4.8).

Place the cleaned glass plate (4.3) on the light source and close the cover.

Determine the light intensity of the cleaned glass plate ( $E_{v2, \text{cleaned glass plate}}$ ) and record the result.

## 10 Evaluation

**10.1** The soot index is determined according to equation 2 made up of the ratio of the light intensity ( $E_v$ ) resulting from the measurements of the sooted ( $E_{v, \text{sooted glass plate}}$ ) glass plate / cleaned ( $E_{v, \text{cleaned glass plate}}$ ) glass plate.

$$Si = \left( 1 - \frac{E_{v, \text{sooted glass plate}}}{E_{v, \text{cleaned glass plate}}} \right) \cdot 100 \quad (2)$$

Where

$Si$	Soot index
$E_{v, \text{sooted glass plate}}$	Light intensity of the sooted glass plate, in cd/m <sup>2</sup>
$E_{v, \text{cleaned glass plate}}$	Light intensity of the cleaned glass plate, in cd/m <sup>2</sup>

**10.2** The hourly soot index is calculated as the ratio of the soot index to the total test time (sum of burning cycles) according to table 2. The hourly soot index is recorded in accordance with equation 3.

$$Si_h = \frac{Si}{t_{b, \text{total}}} \quad (3)$$

Where

$Si_h$	Hourly soot index, in h <sup>-1</sup>
$Si$	Soot index
$t_{b, \text{total}}$	Total burning time of the burning cycles, in h

**10.3** The ratio of the difference of the candle weight before and after burning and the sum of initial and burning periods according to equation 4 is recorded as the hourly fuel consumption ( $f_{c,h}$ ).

$$f_{c,h} = \frac{\Delta w}{t_{b, \text{total}}} \quad (4)$$

Where

$f_{c,h}$	Hourly fuel consumption, in g/h
$\Delta w$	Difference in the candle weight before and after burning, in g
$t_{b, \text{total}}$	Total burning time of the burning cycles and initial burning cycles, in h

## **11 Test report**

The test report serves to identify the tested candle and to record the test results.

The following items shall be included in the test report:

- a) a reference to this European standard;
- b) details of the test sample (e.g. identification, dimensions, weight, etc.);
- c) any defects before testing;
- d) the test results according to this European Standard;
- e) details of any deviations from this European Standard;
- f) name and address of the test facility;
- g) the date of the test.

## Annex A (normative)

### Measurement unit

#### A.1 First operation of the measurement unit

Connect the indication instrument and light source to a suitable source of electrical power and turn on.

NOTE The light source does not reach its final and constant light intensity until minimum 30 min after being switched on. Do not start measuring before a constant value is indicated.

Set the indication instrument at the measuring range of 20,000 cd/m<sup>2</sup> (unit Lux). Adopt the next measuring range for lower values whilst measuring if necessary.

Prior to first use determine the light intensity of the new instrument without any glass plate ( $E_{v,01}$ ) and note it. This value for the new measurement unit should not be less than 1,500 Lux. This value serves as a daily standard for the calibration of the measurement unit (see A.2).

#### A.2 Calibration of the measurement unit

The measurement unit has to be checked daily by the following test measurements before real measuring commences:

NOTE The light source does not reach its final and constant light intensity until minimum 30 min after being switched on. Do not start measuring before a constant value is indicated.

Check the light intensity of the light source without any glass plate ( $E_{v,0}$ ). The intensity has to be at least 50% of the intensity of the new instrument ( $E_{v,01}$ ) (see equation A.1). Otherwise the light source has to be changed.

$$\frac{E_{v,0}}{E_{v,01}} \cdot 100 \geq 50 \% \quad (\text{A.1})$$

Where

$E_{v,0}$  Light intensity without glass plate, in cd/m<sup>2</sup>

$E_{v,01}$  Light intensity without glass plate (first measurement with the new measurement unit), in cd/m<sup>2</sup>

Check the absorption of the inner surfaces of the measurement unit ( $A_i$ ) by comparing the light intensities with glass plate ( $E_{v, glass\ plate}$ ) and with glass plate and calibration disc ( $E_{v, calibration\ disc}$ ). The value  $A_i$  (see equation A.2) shall not deviate by more than 10% of the  $A_i$ -value of a new measurement unit.

$$A_i = \frac{E_{v, calibration\ disc}}{E_{v, glass\ plate}} \quad (\text{A.2})$$

Where

$A_i$  Absorption of the inner surface of the measurement unit, in %

$E_{v, calibration\ disc}$  Light intensity with glass plate plus calibration disc, in cd/m<sup>2</sup>

$E_{v, glass\ plate}$  Light intensity with glass plate, in cd/m<sup>2</sup>