SLOVENSKI STANDARD
SIST ISO 9835:1996

01-oktober-1996

Zunanji zrak - Določanje indeksa črnine dima

Ambient air - Determination of a black smoke index

Air ambiant - Détermination d'un indice de fumée noire

Ta slovenski standard je istoveten z: **ISO 9835:1993**

ICS:

13.040.20 Kakovost okoljskega zraka Ambient atmospheres

SIST ISO 9835:1996 **en**

INTERNATIONAL STANDARD

ISO 9835

First edition
1993-03-15

Ambient air — Determination of a black smoke index

Air ambiant — Détermination d'un indice de fumée noire

Reference number
ISO 9835:1993(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 9835 was prepared by Technical Committee ISO/TC 146, *Air quality*, Sub-Committee SC 3, *Ambient atmospheres*.

Annex A of this International Standard is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Ambient air — Determination of a black smoke index

1 Scope

This International Standard specifies a method for measuring the black smoke index of an ambient air sample. The method is based on the staining effect of particles which is produced when a sample of air is drawn through a filter paper.

The method is intended for the measurement of a black smoke index in the range 6 to 375 in the ambient atmosphere. It is based on the measurement of reflectance. The method does not measure the mass concentration of particles directly.

2 Definition

For the purposes of this International Standard, the following definition applies.

2.1 black smoke: Strongly light-absorbing, particulate material suspended in the ambient atmosphere.

NOTE 1 The major contributor to black smoke is soot particles; i.e. particles containing carbon in its elemental form.

3 Principle and theory

Air is drawn through a filter paper and the reflectance of the stain produced is measured. If it is assumed that reflected light from the surface of the filter paper has passed through the layer of light absorbent particles twice, reflectance from the filter surface is analogous to the absorption of light by particles suspended in air in accordance with the equation

$$R = R_0 \exp\left(\frac{-2aV}{A}\right) \quad \ldots (1)$$

where

R is the intensity of reflected light from the surface of a stained paper;

R_0 is the intensity of reflected light from the surface of a clean paper;

A is the area of the stain on the filter paper, in square metres;

V is the volume sampled, in cubic metres;

a is the absorption coefficient, in reciprocal metres.

Thus, rearranging equation (1):

$$a = \frac{A}{2V} \times \ln\left(\frac{R_0}{R}\right) \quad \ldots (2)$$

The method specified in this International Standard can be used to measure the absorption coefficient on any filter material, but the conversion of absorption coefficient or extinction coefficient to what is, by convention, known as the black smoke index, is purely an arbitrary operation which is carried out by reference to tables or graphs. For further explanations, see annex A.

4 Apparatus

4.1 Sampling equipment. The sampler shall be designed for daily operation, or it shall be of an automatic type for continuous operation. Flow diagrams of alternative arrangements of sampling equipment are shown in figure 1. Details of the sampling equipment are given in 4.1.1 to 4.1.6.

4.1.1 Air intake, a conical funnel of 30 mm to 50 mm diameter that is constructed of polyvinylchloride. The funnel shall be mounted vertically with the mouth downwards at a height of not less than 2,5 m and not greater than 5 m above the ground. The inlet shall be located at least 1 m horizontally from any external walls.

4.1.2 Connection tubing, constructed of polyvinylchloride, of internal diameter 8 mm ± 1 mm and not greater than 6 m in length. Bends shall be avoided if possible but, if unavoidable, shall have a radius greater than 50 mm.

4.1.3 Filter unit. The filter holder shall be constructed of an electrically conducting and chemically inert material (with respect to the atmosphere likely to be encountered). The area of the aperture shall be 5 cm^2 + 5 %. The leakage across the filter and valves (if used) shall not exceed 2 % of the total flow rate. The filter holder should be of a design which will provide a homogeneous particle layer on the surface of the filter medium.

The homogeneity of the particle layer can be checked by measuring the reflectance at several points across the diameter of the stain produced by sampling particles using the filter holder. The variation in reflectance across the stain shall not exceed 1 percentage unit of reflectance.

4.1.4 Filter material. The filter membrane shall have a collection efficiency of as close to 100 % as possible in the 0,1 micron to 5 micron particle size range. Variations in reflectance across the whole surface area shall not exceed 1 reflectance unit. In addition, the filter material shall be suitable for a flow rate of 2 m^3/d.

NOTE 2 The reflectance of unused filters may vary from batch to batch, and it is therefore necessary to check and adjust for the variability of the filters before use.

4.1.5 Sampling pump, capable of delivering up to 2,0 l/min of air with the filter in line. If a membrane pump is used, a 0,2 litre ballast shall be incorporated to minimize pressure fluctuations. The pump is placed before the flow or volume meter (see figure 1).

4.1.6 Volume measurement and flow rate control, consisting of a sampler equipped with a flow controller capable of keeping the flow rate constant to within ± 5 % of the measured flow. Measure the volume sampled by either

a) recording the elapsed time and calculating the volume sampled under the control of the flow controller; or

b) reading the volume directly from a dry gasmeter having an accuracy of at least 5 % of the measured volume (the sampling flow rate shall be 2 m^3/d ± 0,2 m^3/d).

4.2 Reflectometer, consisting of a light source and detector and having either an analogue or digital readout of either the percentage reflectance (linear scale; 0 to 100 % reflectance) or the extinction coefficient (logarithmic scale; 0 to infinity) type.

The points on the density chart[1] shall be within the limits shown in figure 2.

Instruments designed according to the requirements mentioned in this subclause shall be capable of measuring the absorption coefficient with a precision of better than 5 % at absorption coefficients greater than $1 \times 10^{-5} m^{-1}$.

5 Procedure

5.1 Sampling

Assemble the sampling train in the order illustrated in figure 1 using the specified connection tubing (4.1.2) for all connections. Place a clean sheet of filter paper (4.1.4) in the filter unit. If the two faces of the paper do not have the same texture, place the paper so that the suspended particulate matter is collected on the smoother surface.

Assemble the filter unit (4.1.3) according to the manufacturer's instructions. Check the assembled equipment for leakage.

Record the initial reading of the gasmeter (if fitted).

Start the sampling pump (4.1.5), adjust the sampling rate to 1,4 l/min (2 m^3/d) and note the starting time. Sample for 24 h.

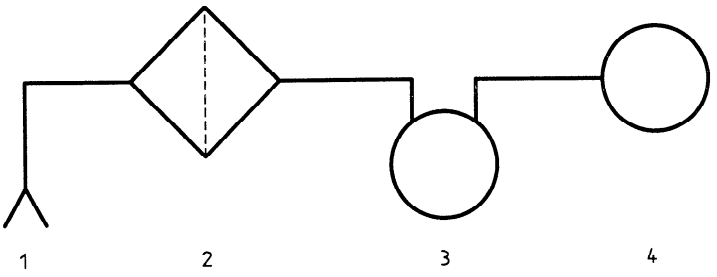
At the end of the sampling period, record the flow rate and time, switch off the sampling pump and record the final reading of the dry gasmeter (if fitted) and the sampling period to the nearest hour and minute.

Calculate the volume sampled, in cubic metres, using the flow rate and the sample duration or using the readings of the dry gasmeter. (See also 4.1.6.)

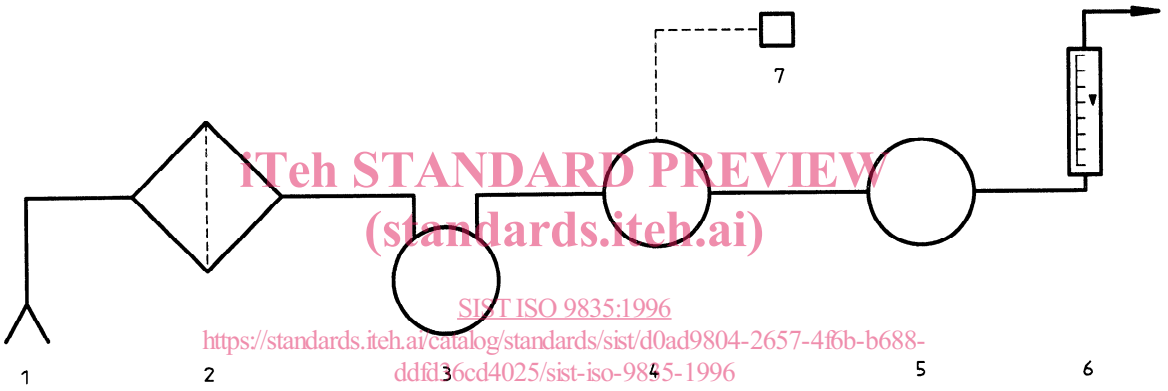
5.2 Calibration of the reflectometer

Calibrate the reflectometer according to the manufacturers' instructions.

1) Kodak Publication No. Q-16.



a) Alternative 1



b) Alternative 2

Key

1 Air intake

2 Filter clamp

3 Sampling pump

4 Dry gasmeter

5 Flow controller

6 Variable area flowmeter

7 Elapsed time meter

Figure 1 — Alternative sampling arrangements for black smoke measurement

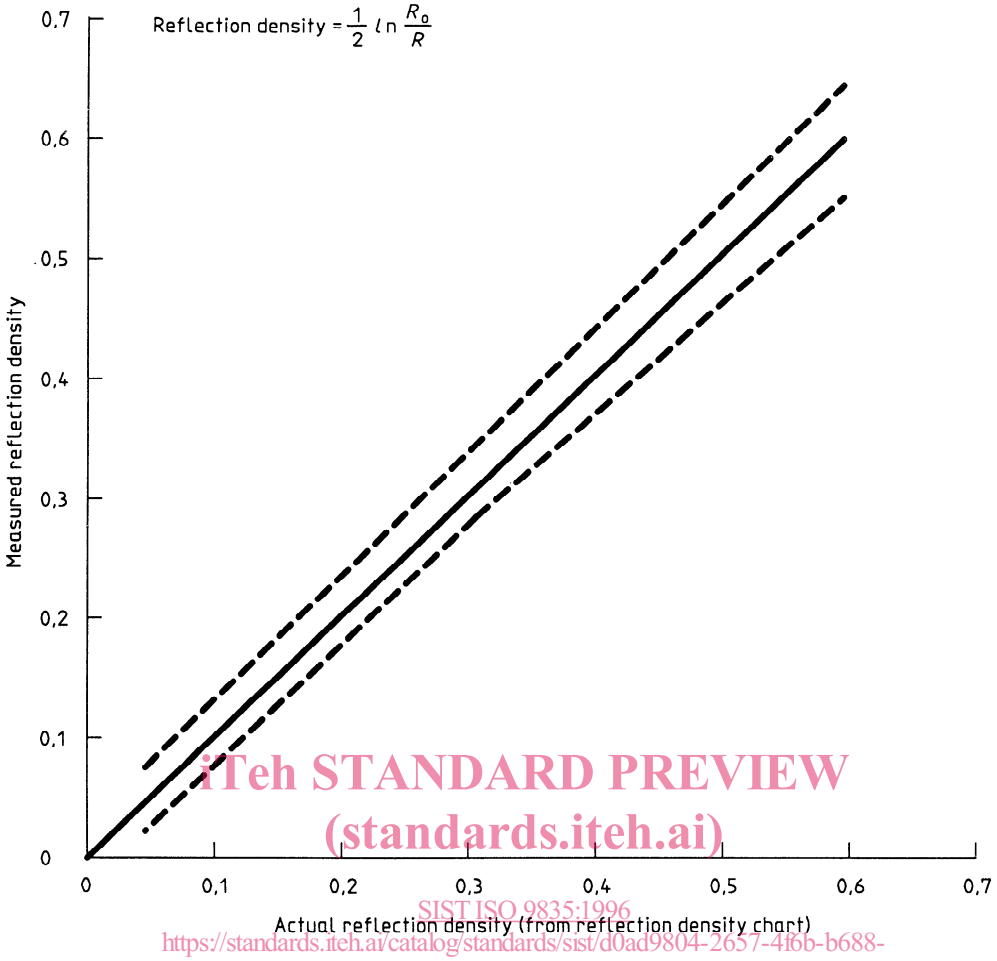


Figure 2 — Reflectometer response

5.3 Measurement of the reflectance of smoke stains

5.3.1 Calibrate the reflectometer at least once per month using the procedure described in 5.2.

5.3.2 Set the reflectometer to 100 % reflectance (zero absorbance) on a clean filter paper according to the reflectometer manufacturer's instructions.

5.3.3 Replace the clean filter paper by an exposed one (see 5.1), measure the reflectance according to the manufacturer's instructions and record the reflectometer reading (which will be less than 100 % reflectance or more than zero absorbance).

The measured reflectances shall lie in the range 35 % to 95 % reflectance, corresponding to a range of 0,64 to 13,13 × 10^{-5} for the absorption coefficient.

5.3.4 Check the 100 % adjustment of the reflectometer on a clean filter paper at frequent intervals, for example at least after every 10 smoke stains, and readjust if necessary.

6 Expression of results

6.1 Calculation

Calculate the absorption coefficient a, in reciprocal metres, using equation (2)

$$a = \frac{A}{2V} \times \ln\left(\frac{R_0}{R}\right) \qquad \ldots (3)$$

where

R is the reflectance of the stained paper, in percentage of R_0;

R_0 is the reflectance of the clean reference paper (100 by definition);

V is the volume sampled, in cubic metres;

A is the area of the stain on the filter paper, in square metres.

Report the absorption coefficient to the first decimal place.

NOTE 3 Table A.1 may be used to convert the absorption coefficient, a, to the black smoke index, in line with the OECD or EEC reference methods.

6.2 Precision and accuracy

The reflectance of filter stains can be read to 1 reflectance unit with 95 % confidence. The resulting confidence limits for the absorption coefficient, a, are given in table 1.

Table 1 — Confidence limits for absorption coefficients

Reflectance, R %	a [1] $\times 10^{-5}$	Confidence limits	
		Δb	$\%b$
95	0,65	0,13	20,3
80	2,83	0,16	5,8
70	4,52	0,18	4,0
60	6,47	0,21	3,3
50	8,78	0,25	2,9
40	11,61	0,31	2,7
36	12,94	0,35	2,7

1) For $A = 5{,}07 \times 10^{-4}$ m^2 and $V = 2$ m^3

7 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) a complete identification of the air sample, including date, time and location;

c) the type of filter paper and reflectometer used;

d) the results obtained, including the volume sampled, the sample duration, the flow rate and the measured reflectance (or absorbance);

e) any unusual features noted during the determination;

f) any operation carried out that is not specified in this International Standard;

g) the location of any sources of black smoke close to the sampler which may have contributed to the results;

h) any other information relevant to the method.