SIST

SLOVENSKI STANDARD
SIST EN 1093-4:1998

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Varnost strojev - Vrednotenje emisije nevarnih snovi, ki jih prenaġa zrak - 4. del: Uļ inkovitost zajemanja odsesovalnega sistema - Metoda sledenja

Safety of machinery - Evaluation of the emission of airborne hazardous substances - Part 4: Capture efficiency of an exhaust system - Tracer method

Sicherheit von Maschinen - Bewertung der Emission von luftgetragenen Gefahrstoffen - Teil 4: Erfassungsgrad eines Absaugsystems - Tracerverfahren

Sécurité des machines - Evaluation de l'émission de substances dangereuses véhiculées par l'air - Partie 4: Efficacité de captage d'un systeme d'aspiration - Méthode par traçage

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ICS:

13.040.40	Emisije nepremiļ nih virov	Stationary source emissions
13.110	Varnost strojev	Safety of machinery

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English version

Safety of machinery - Evaluation of the emission of airborne hazardous substances - Part 4: Capture efficiency of an exhaust system - Tracer method

Sécurité des machines - Evaluation de l'émission de substances dangereuses véhiculées par l'air - Partie 4: Efficacité de captage d'un système d'aspiration - Méthode par traçage

Sicherheit von Maschinen - Bewertung der Emission von luftgetragenen Gefahrstoffen - Teil 4: Erfassungsgrad eines Absaugsystems - Tracerverfahren

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CEN

European Committee for Standardization
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Contents list

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 114 "Safety of Machinery", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 1996, and conflicting standards shall be withdrawn at the latest by September 1996.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This standard describes a method for the measurement of the capture efficiency of an exhaust system installed on a machine. This method is based on a tracer technique and may be operated in all types of test environment (bench, room and field, see ENV 1093-1).

This technique is applicable only if the tracer shows aerodynamic behaviour comparable with the real pollutant (see 7.1.1).

The measurement of the capture efficiency of an exhaust system can serve for:

a) the evaluation of the performance of an exhaust system of a machine;

b) the evaluation of the improvement of an exhaust system;

c) the comparison of exhaust systems for machines of similar design;

d) the ranking of exhaust systems according to their capture efficiency;

e) the determination of the air flow rate of an exhaust system to achieve a given level of capture efficiency;

f) the determination of the state of the art of exhaust systems for machines with respect to the capture efficiency.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1	Safety of machinery - Basic concepts - General principles for design - Part 1: Basic terminology, methodology
EN 292-2	Safety of machinery - Basic concepts - General principles for design - Part 2: Technical principles and specifications
ENV 1093-1	Safety of machinery - Evaluation of the emission of airborne hazardous substances - Part 1: Selection of test methods
ISO 4053-1	Measurement of gas flow in conduits - Tracer methods - Part 1: General

3 Definitions

For the purpose of this European Standard the following definitions apply:

3.1 capture efficiency of an exhaust system η_c: The ratio of the mass-flowrate of a specified pollutant directly collected by the exhaust system to the uncontrolled mass-flowrate of this pollutant emitted from the machine.

3.2 tracer technique: The use of substances with an aerodynamic behaviour comparable with as the hazardous substance under consideration and which can be reliably measured.

4 Principle

The principle of the measurement method consists of:

a) emitting a tracer simulating the aerodynamic behaviour of the real pollutant, with the tracer flow rate (q_E);

b) measuring the flow rate (q_C) of the tracer collected by the exhaust system.

5 Simplified expression of the capture efficiency

The capture efficiency expressed as a percentage is:

$$\eta_c = \frac{q_C}{q_E} \times 100 \qquad (1)$$

The tracer flow rate (q_E) is determined by emitting the tracer at constant flow rate directly into the exhaust duct and by measuring the average tracer concentration in a cross section of the duct then:

$$q_E = Q(C_2 - C_1) \qquad (2)$$

where:

- Q is the average air flow rate in the duct during the measurement period of (q_E);
- C_1 is the average ambient concentration of the tracer before the measurements (background level);
- C_2 is the average concentration of the tracer in the duct (emission of tracer in the duct).

The tracer flow rate (q_C) is determined by emitting the tracer at constant flow rate (q_E) at a characteristic point or zone of the emission of the real pollutant (e. g. at the furthest locations in the emission zone from the exhaust system) and by measuring the average concentration of tracer in the same points of the duct:

$$q_C = Q'(C_3 - C_1') \qquad (3)$$

where:

Q' is the average air flow rate in the duct during the measurement period of (q_C);

C'_1 is the average ambient concentration of the tracer after the background level is stabilized;

C_3 is the average concentration of the tracer in the duct (emission at a selected location).

The capture efficiency is expressed as a percentage as follows:

$$\eta_c = \frac{q_C}{q_E} \times 100 = \frac{Q'(C_3 - C'_1)}{Q(C_2 - C_1)} \times 100 \quad (4)$$

If the exhaust flow rate can be considered as being constant, than Q = Q', and the expression can be simplified:

$$\eta_c = \frac{C_3 - C'_1}{C_2 - C_1} \times 100 \quad (5)$$

The capture efficiency is then determined by measuring only concentrations in the exhaust duct.

6 Test method

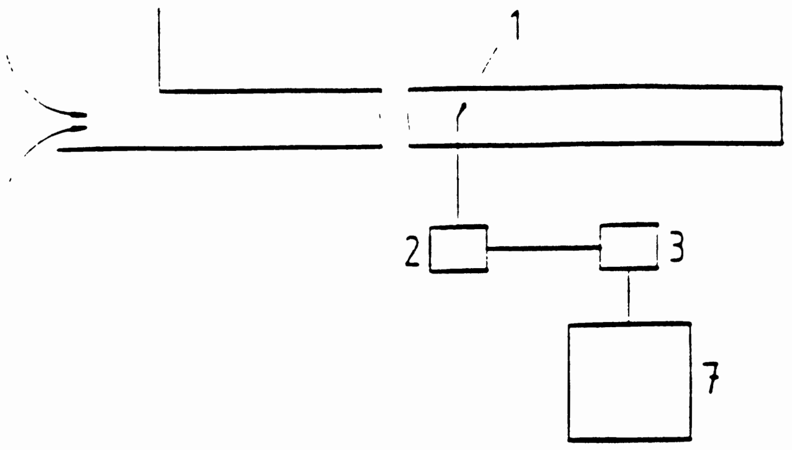
6.1 General procedure

The measurement procedure is illustrated by figures 1 and figure 2 shows a typical test record.

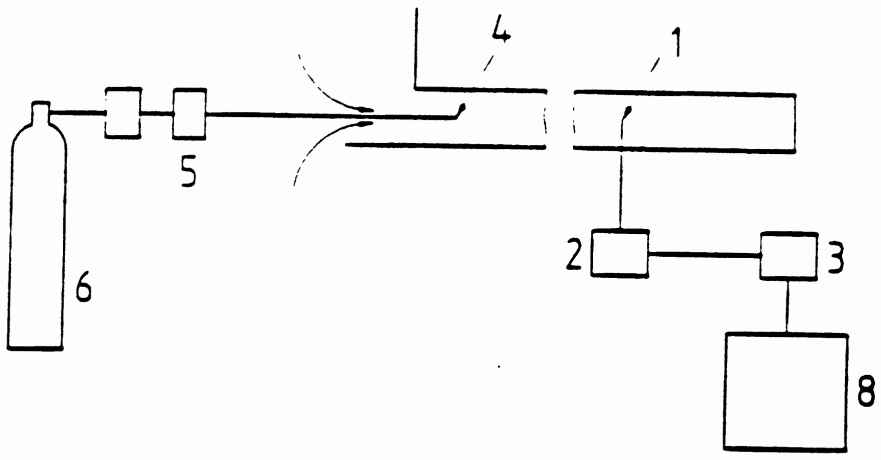
To measure the concentration by sampling the air in the duct, it is assumed that the tracer is well mixed with the air. In the case of straight ducts the procedures described in ISO 4053-1 shall be used.

NOTE: Devices can be added to the duct to reduce the mixing length.

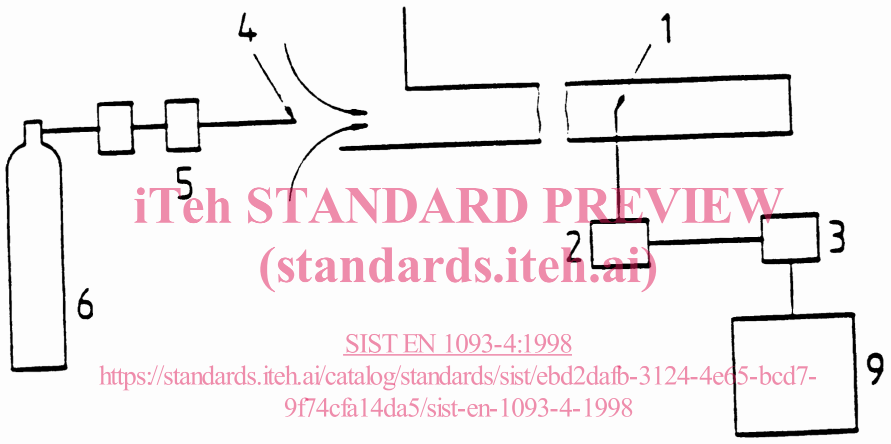
At least three tests shall be performed.



Phases 1 and 4: Measurement without tracer emission



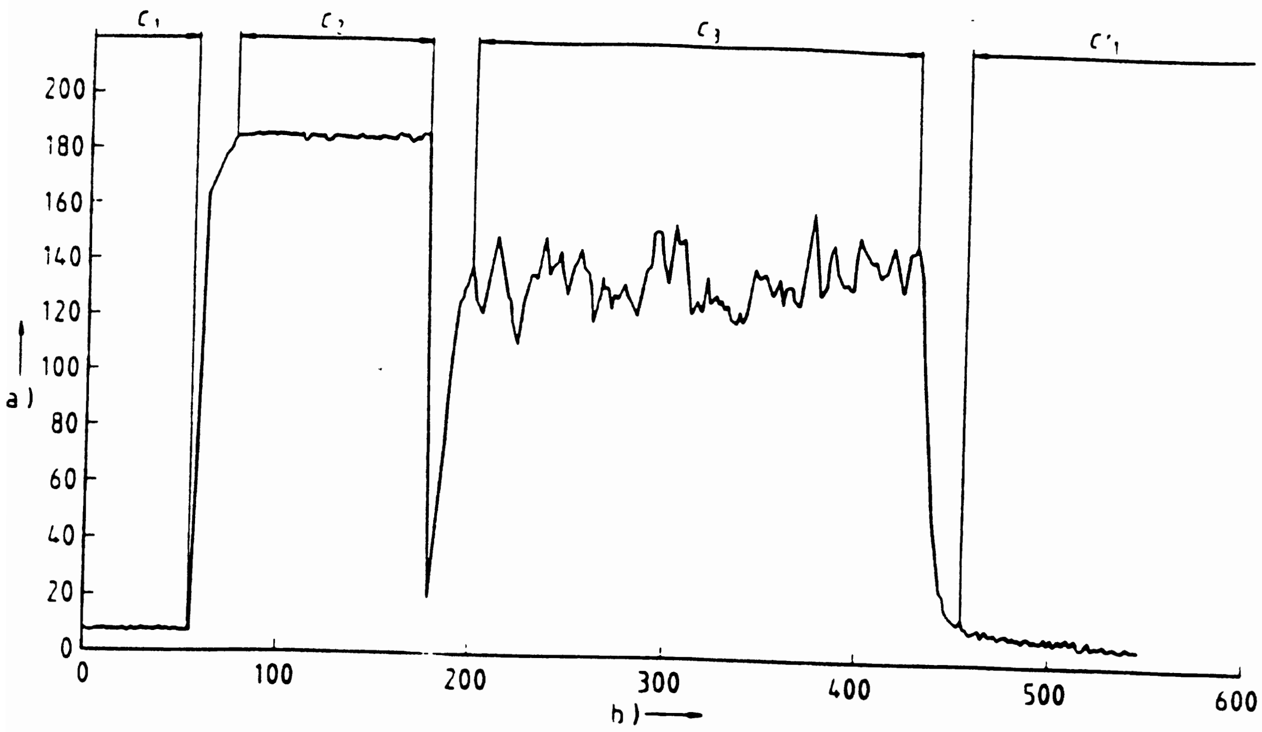
Phase 2: Measurement with tracer emission in the duct



Phase 3. Measurement with tracer emission simulating the real pollutant

1 sampling
2 pump
3 analyzer
4 injection
5 tracer gas flow meter
6 tracer gas cylinder (pure or diluted tracer gas
7 ambient concentration C_1 or C'_1
8 concentration C_2
9 concentration C_3

Figure 1: Measurement procedure for a simple exhaust system using a tracer gas



a) tracer concentration
b) time in seconds

Figure 2: Typical test recording

6.2 Measurement of the concentration (C_3)

Considering an emitter whose flow rate changes suddenly from 0 to (q_E), the concentration (C_3) rises progressively as a function of time. The curve of variation of (C_3) roughly shows two time constants:

- the first, relatively small, corresponds to the accumulation of tracer in the volume directly under the influence of the exhaust system; .

- the second, which is larger, corresponds to the accumulation of tracer in the rest of the room. A part of the tracer, escaping from the zone of direct influence of the exhaust system, is secondarily and indirectly collected over a longer period of time.

Since the efficiency of a system is based on the direct collection of the pollutant, the efficiency is defined on the basis of the determination of the value of (C_3) corresponding to the first time constant.

In practice, and except for very small rooms, the time constant of the room is much larger than the time constant of the collection system, so that the measurement may be facilitated by averaging the value of the efficiency over a time interval of a few minutes after obtaining the first quasi equilibrium state. In small rooms an increase in the ambient concentration can impair the quality of the measurement. For this reason, the measurement should only be accepted if the ratio

$$\frac{C_1 - C'_1}{C_2 - C_1}$$

is lower than 0,05. The concentration C'_1 should be measured 1 minute after dosing of the tracer is stopped.

Because of the fluctuations in the response, as can be observed in figure 2, the concentration C_3 should be established as an average over a reasonable period of time. For a given measurement, the effective averaging period can be calculated as the time constant for the measuring system multiplied by the number of samples taken. To allow statistical analyses of the signal, leading to results such as minimum capture efficiency or relative standard deviation, the time constant of the measuring system should be adjusted to a defined value. This adjustment can be achieved by use of a buffer volume on the sampling line or by use of a digital filter. The time constant should be adjusted to 10 s. The interval between successive samples should be equal to or larger than the time constant for the measuring system in use.

Statistical analysis of the signal C_3 can determine the concentration of C_3(95 %). This is the value of C_3 which is exceeded for 95 % of the specified measurement time. This value leads to the minimum capture efficiency, the calculation of which is given by the following formula:

$$\eta_c(95\%) = \frac{C_3(95\%) - C'_1}{C_2 - C_1} \qquad (6)$$

Assuming the distribution of C_3 is Gaussian, C_3(95 %) can be derived from the mean value and the standard deviation of C_3 using the equation:

$$C_3(95\%) = C_3 - 1{,}64 \times \sigma(C_3) \qquad (7)$$

The measurement result shall always be stated together with the uncertainty of the result. The uncertainty can be calculated according to annex A.

NOTE: 95 % is a typical percentage, but other values above 75 % may be used.

It is also possible to describe the performance of the exhaust system by the relative standard deviation which is calculated as the ratio of the estimated value of the standard deviation of C_3 to the mean value of C_3.

6.3 Application to a specific group of machines

Each new type C standard based on this standard dealing with a given group of machines shall supply additional information about more specific test conditions, particularly concerning the conditions of tracer generation and sampling, the test duration, the operating conditions of the machine.

7 Control parameters and influencing factors

This clause deals with the control parameters which can be adjusted to simulate the actual pollutant emission accurately and the parameters that influence the measurement and characterize the situation during the measurement period.

7.1 Control parameters

7.1.1 Type of tracer

- Gaseous pollutant

Since the turbulent diffusion coefficient of a gas, measured on site, is much higher than its molecular diffusion coefficient, it can be considered that the overall behaviour of all gases is practically identical from the standpoint of total mass transfer. In these conditions, a tracer gas shall be selected in accordance with the following criteria:

a) nil or very low toxicity;

b) chemical stability at the intended process temperature;

c) non-interference with pollutants present in the room;

d) low background level.

Since the capture efficiency may depend on the density of the tracer, one should check that emission conditions get close to the real ones [1]).

- Aerosol pollutant

On the basis of identical considerations about the diffusion coefficients, it may be considered that fine aerosols, particularly significant in industrial hygiene, may be simulated by tracer gas. Above 3 µm to 4 µm, the difference observed in transfer may increase progressively with particle size; however, up to 10 µm, the

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[1]) In some cases, the tracer gas has to be diluted before emission. The choice of the tracer gas and associated analyzer depends, in particular, on the desired accuracy, the measurement range, and the cost. The gases normally used are helium, sulfur hexafluoride, nitrous oxide.