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Safety of machinery — Evaluation of the emission of airborne hazardous substances —

Part 4: Tracer method for the measurement of the capture efficiency of an exhaust system

Sécurité des machines — Évaluation de l'émission de substances dangereuses véhiculées par l'air —

Partie 4: Méthode par traceur pour le mesurage de l'efficacité de captage d'un système d'échappement

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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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 29042-4 was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

ISO 29042 consists of the following parts, under the general title *Safety of machinery — Evaluation of the emission of airborne hazardous substances*:

— *Part 1: Selection of test methods*

— *Part 2: Tracer gas method for the measurement of the emission rate of a given pollutant*

— *Part 3: Test bench method for the measurement of the emission rate of a given pollutant*

— *Part 4: Tracer method for the measurement of the capture efficiency of an exhaust system*

The following parts are under preparation:

— *Part 5: Test bench method for the measurement of the separation efficiency by mass of air cleaning systems with unducted outlet*

— *Part 6: Test bench method for the measurement of the separation efficiency by mass of air cleaning systems with ducted outlet*

— *Part 7: Test bench method for the measurement of the pollutant concentration parameter*

A room method for the measurement of the pollutant concentration parameter and a decontamination index are to form the subjects of future parts 8 and 9.

Introduction

The structure of safety standards in the field of machinery is as follows:

a) type-A standards (basic safety standards) giving basic concepts, principles for design, and general aspects that can be applied to all machinery;

b) type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:

   — type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

   — type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure-sensitive devices, guards);

c) type-C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This part of ISO 29042 is a type-B standard as stated in ISO 12100-1.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines which are covered by the scope of a type-C standard and which have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

ISO/TC 199 has a mandate in this area to produce type-A and type-B standards, which will allow verification of conformity with the essential safety requirements.

ISO 29042-4 is based on EN 1093-4:1996, amended by Amendment 1:2008, published by the European Committee for Standardization (CEN).

Safety of machinery — Evaluation of the emission of airborne hazardous substances —

Part 4: Tracer method for the measurement of the capture efficiency of an exhaust system

1 Scope

This part of ISO 29042 specifies a method based on a tracer technique for measuring the capture efficiency of an exhaust system installed on a machine. It is applicable to all types of test environment — test bench, room or field (see ISO 29042-1) — but is only applicable if the tracer shows aerodynamic behaviour comparable to that of the real pollutant.

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

a) evaluation of the performance of a machine's exhaust system,

b) evaluation of the improvement of an exhaust system,

c) comparison of exhaust systems for machines of similar design,

d) ranking of exhaust systems according to their capture efficiency,

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

f) determination of the state-of-the-art of machine exhaust systems with respect to capture efficiency.

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.

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100-1 and the following apply.

3.1
capture efficiency
η_C
ratio of the mass flow rate of a given pollutant directly collected by an exhaust system to the uncontrolled mass flow rate of this pollutant emitted from the machine

3.2
tracer technique
use of gaseous substances with an aerodynamic behaviour comparable with the hazardous substance under consideration and for which concentrations 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, η_c, expressed as a percentage, is given by Equation (1):

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

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 using Equation (2):

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

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 a constant flow rate, q_E, at a characteristic point or zone of the emission of the real pollutant (e.g. at the locations in the emission zone furthest from the exhaust system) and by measuring the average concentration of tracer in the same points of the duct, then using Equation (3):

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

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 using Equation (4):

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

If the exhaust flow rate can be considered as being constant, then $Q = Q'$, and the expression can be simplified as Equation (5):

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

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 shown in Figure 1, while Figure 2 shows a typical test recording.

In order to be able to measure the concentration by sampling the air in the duct, it is assumed that the tracer is well mixed with the air.[1)]

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

At least three tests shall be performed.

1) In EN 1093-4:1996, on which this part of ISO 29042 is based, a recommendation was given for the use of the procedures for straight ducts described in ISO 4053-1:1977. ISO 4053-1 has since been withdrawn and is no longer publicly available; at the time of publication of this part of ISO 29042, it had not been replaced by another International Standard.