INTERNATIONAL STANDARD

ISO 29042-1

First edition
2008-09-15

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

Part 1: Selection of test methods

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

Partie 1: Choix des méthodes d'essai

Reference number
ISO 29042-1:2008(E)

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Published in Switzerland

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 29042-1 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*

Room method for the measurement of the pollutant concentration parameter and 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 control devices, 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 document is a type-B standard as stated in ISO 12100.

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 29042-1 is based on EN 1093-1, published by the European Committee for Standardization (CEN) which is at the same time subject to revision.

The concentration level of substances resulting from emission of airborne hazardous substances from machines depends upon factors including:

- the emission rate of airborne hazardous substances (“pollutants”) from the machine under examination, depending of the type of process and the production rate of the machine;

- the performance of the pollutant control system associated with the machine and, in the case of air recirculation, the performance of the separation system;

- the surrounding conditions, especially the air flow pattern, which can reduce the pollution (efficient general ventilation) or increase it (disturbing air, crossdraughts);

- the worker's location in relation to the machine and its pollutant control system, and taking into account the workers movements;

- the quality of maintenance; poor quality has generally an adverse effect on the performance of the pollutant control and the separation systems.

This International Standard concerns the first two points in this list and forms only one part of a comprehensive risk assessment. It is not for a risk assessment of the workplace. Evaluation of the parameters defined in this International Standard leads to an evaluation of the performance of the machine and its associated pollutant control system.

This International Standard can be used as a part of verification described in ISO 14123-2.

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

Part 1: Selection of test methods

1 Scope

This part of ISO 29042 specifies parameters which can be used for the assessment of the emission of pollutants from machines or the performance of the pollutant control systems integrated in machines. It gives guidance on the selection of appropriate test methods according to their various fields of application and types of machine including the effects of measures to reduce exposures to pollutants. The test methods are given in other parts of this International Standard (see Table 1).

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
uncontrolled emission rate of a given pollutant
$\dot{m}_{\mathrm{u}}$
mass of pollutant emitted from the machine into the space around the machine per unit of time

NOTE Any measures to reduce the air pollution around the machine (e.g. capture devices, containment equipment, wetting process) should not be used or should be de-activated.

3.2
controlled emission rate of a given pollutant
$\dot{m}_{\mathrm{K}}$
mass of pollutant emitted from the machine into the space around the machine per unit of time, taking into account the effects of measures to reduce the air pollution

NOTE Any measures to reduce the air pollution around the machine (e.g. capture devices, containment equipment, wetting process) should be used or activated.

3.3
capture efficiency
η_C
⟨pollutant control system⟩ ratio of the mass flow rate of a given pollutant directly collected by the pollutant control system to the uncontrolled mass flow rate of this pollutant emitted from the machine

NOTE 1 The capture efficiency, as a percentage, can be calculated by the following equation:

$$\eta_C = \frac{\dot{m}_u - \dot{m}_k}{\dot{m}_u} \times 100 \quad (1)$$

This equation is applicable only if $\dot{m}_u - \dot{m}_k$ represents the pollutant mass flow rate directly captured. This parameter is not usable when the amount of emission is affected by the control system.

NOTE 2 Where the pollutant control system is an exhaust system and provided comparable discharge and flow patterns of the real pollutant can be simulated by a tracer technique the equation becomes:

$$\eta_C = \frac{q_C}{q_E} \times 100 \quad (2)$$

where

q_C is the flow rate of tracer collected by the exhaust system during operation;

q_E is the flow rate of tracer emitted (measured by emitting the tracer directly into the exhaust system during the first phase).

NOTE 3 For further details see ISO 29042-4:—, Clause 5.

3.4
separation efficiency by mass
η_S
⟨air cleaning system⟩ ratio of the mass of pollutant retained by the air cleaning system (m_3) to the mass of pollutant entering the air cleaning system (m_1) during a given period

NOTE 1 For special applications the number of fibres or particles is measured instead of the mass.

NOTE 2 The separation efficiency of an air cleaning system, as a percent mass fraction, can be calculated by the following equation:

$$\eta_S = \frac{m_3}{m_1} \times 100 \quad (3)$$

NOTE 3 In certain cases it can be necessary to consider only that part of pollutants (e.g. size of particles) which is actually hazardous for exposed persons; e.g. separation efficiency of a separation system against hazardous dust is measured as a function of particle size — otherwise the results will possibly not be reliable for health and safety purposes.

3.5
pollutant concentration parameter
P_C
the measured concentration of a given pollutant in defined position(s) near the machine

3.6
decontamination index
I_A
the average of the ratio, obtained at a number of specified locations in the surroundings, of the ambient air quality improvement to the real pollutant mean concentration with the pollutant control system not in operation

NOTE 1 Corrections can be necessary to take into account air pollution caused by other operations ("the background level").

NOTE 2 The decontamination index can be calculated by the following equation:

$$I_{\mathrm{A}} = \frac{1}{n}\sum_{i=1}^{n}\frac{C_{\mathrm{a}i} - C_{\mathrm{m}i}}{C_{\mathrm{a}i} - C_{\mathrm{f}i}} \tag{4}$$

where

$C_{\mathrm{a}i}$ is the real pollutant concentration measured at a specified location in the surrounding under the following condition: machine in operation, pollutant control system not in operation;

$C_{\mathrm{m}i}$ is the real pollutant concentration measured at a specified location in the surrounding under the following condition: machine and pollutant control system in operation;

$C_{\mathrm{f}i}$ is the real pollutant concentration measured at a specified location in the surrounding under the following condition: machine and pollutant control system not in operation (“the background level”);

n is the number of specified locations.

NOTE 3 When the “background level” is negligible, the decontamination index reduces to:

$$I_{\mathrm{A}} = 1 - \frac{1}{n}\sum_{i=1}^{n}\frac{C_{\mathrm{m}i}}{C_{\mathrm{a}i}} \tag{5}$$

4 Types of test methods

4.1 General

When particle size distribution is determined at the same time as pollutant concentration, an assessment parameter for each size fraction can be defined. For the determination of each assessment parameter (see Clause 3), different test methods can be considered. The test methods should be selected according to the following criteria:

— the nature of pollutant used;

— the nature of the test environment.

International Standards suitable for the measurement of fluid flow rates are ISO 3966, ISO 5167-1 and ISO 5168.

4.2 Nature of pollutant used

As far as possible the real pollutant should be used for the testing. However, in some cases tracer techniques allow a more convenient testing. The addition of tracer material to the real pollutant requires several conditions to be met, in particular comparable discharge and flow patterns of the real pollutant and the tracer material, respectively.

Depending on the test method, two types of pollutants shall be considered:

— the real pollutant which may be an aerosol (solid or liquid) or a gas;

— a tracer material simulating the real pollutant.

When determining the emission rate of real pollutant without any air flow measurement, the real pollutant and the tracer material are simultaneously used.

The measurements of concentrations can be carried out:

— in ducts together with air flow rate measurements;

— at locations surrounding the machine under examination.

4.3 Nature of the test environment

4.3.1 General

Two main types of environmental test conditions may be considered, and, in some cases, can lead to different test methods.

4.3.2 Laboratory methods

4.3.2.1 Test bench method

The tests are conducted in a cabin specially designed to these tests or measurements, and of known and limited dimensions.

The cabin contains a single machine in order to avoid any interference from other machines on the pollution around the tested machine and on the air flow rate through the pollutant control system.

The air flow pattern around the machine should be maintained by the provision of specified general ventilation of the cabin.

NOTE In this type of method, the conditions of general ventilation, as well as the operating conditions of the machine, are fixed and, to some extent, arbitrary. Consequently, most of the time they are not representative of the actual situations encountered in practice.

4.3.2.2 Room method

The tests are conducted in a room specially devoted to these tests or measurements, and located in a laboratory or on site in an industrial setting.

Only one machine should be run at a time. More precise control of the general and local ventilation can be achieved than in the field. Since the location of the machine is not fixed, the air flow pattern around the machine shall be checked to determine the influence of crossdraughts.

NOTE In this type of method, the conditions of general ventilation, as well as the operating conditions of the machine, are fixed and, to some extent, arbitrary. Consequently, they are not in general representative of the actual situations encountered in practice.

4.3.3 Field method

Many machines cannot be tested in a cabin (see 4.3.2.1) or a room (see 4.3.2.2) because they are too large, too difficult to handle or have special installation or process requirements. Tests may be performed on machines in the places where they are installed.

Performing field tests on machines in their usual working environment is of particular importance because disturbances occurring in real situations will be taken into account (e.g. crossdraughts).

Care should be taken prior and during the test to determine the operating conditions of the machine under examination and of its pollutant control system, as well as operating conditions of the other machinery, the pollution of which can affect the results.

NOTE This effect can be avoided by using a suitable tracer method.

The operating conditions of the machine under examination and the other equipment shall be recorded.

Additional measurements can also be needed to evaluate the characteristics of the general ventilation including air crossdraughts. These crossdraughts, due for instance to the opening of a door, can drastically disturb the air flow pattern around the machine.

4.4 Summary of methods

Table 1 presents the different methods dealt with in the individual parts of ISO 29042.

Each identified method is described in detail in the part of ISO 29042 indicated in Table 1. Additional information about more specific test conditions will be provided in each new type-C standard dealing with a specific category of machinery.

Table 1 — Summary of methods

Assessment parameters		**Nature of pollutant**	**Chosen method**		
			Test bench method	**Room method**	**Field method**
Emission	Emission rate	Tracer and pollutant	—	ISO 29042-2 [a]	
		Pollutant	ISO 29042-3 [a]	—	—
	Pollutant concentration	Pollutant	ISO 29042-7 [a]	ISO 29042-8 [a]	—
Capture	Efficiency	Tracer	ISO 29042-4 [a]		
		Pollutant	—	—	—
	Decontamination index	Pollutant	—	ISO 29042-9 [a]	
Separation	Efficiency	Pollutant	ISO 29042-5 [a] and ISO 29042-6 [a]	—	—

[a] Under preparation.

5 Basis for selection of test methods

5.1 General

Where several methods seem to be applicable, the selection should be made based on considerations including:

— determination of assessment parameters providing comparison between machines and between pollutant control systems;

— relevance of the chosen methods to the foreseeable working situations of the machine.

5.2 Selection relative to the assessment parameter

The selection of the most suitable parameter depends on the type of information that is required. This requirement can be satisfied by the determination of one or more of the assessment parameters.

a) A requirement can be the overall evaluation of the emission of a given pollutant for a defined machine including its pollutant control system.

   This is given by

   — the controlled emission rate of this given pollutant (m_k),

   or indicated by

   — the pollutant concentration parameter (P_c).

b) When the information concerns either the capture device, or the separation equipment or, more generally, the pollutant control system, a single parameter is sufficient to assess the performance:

- for capture device, the capture efficiency (η_c);
- for separation equipment, the separation efficiency by mass (η_s);
- for the pollutant control system of a given machine and without air recirculation, the decontamination index I_A.

c) For a more analytical approach of the same requirement where the contribution of each component (machine itself, capture device, separation equipment) will be determined, two or three parameters will need to be measured:

- the uncontrolled emission rate of a given pollutant ($\dot{m}_u$);
- the capture efficiency (η_c);
- the separation efficiency by mass (η_s).

5.3 Selection relative to the test environment

According to the criteria given in 5.2, the selection can be based on practical and obvious considerations such as:

- size of the machine;
- ease of handling of the machine;
- ease of installation, including its pollutant control system;
- ease of operation;
- nature of pollutant: toxicity and complexity of concentration measurement.

NOTE Some of these difficulties can be overcome by using a tracer method.

When a test chamber is to be used, a maximum cross-sectional area of the machine equal to a fifth of the cross-sectional area of the test chamber is recommended.

5.4 Selection relative to the nature of the pollutant

By definition, the real pollutant is essential for the determination of emission rates, separation efficiency, pollutant concentration parameter and decontamination index.

In some cases tracer techniques allow a convenient determination of some of the parameters due to:

- lack of experimental difficulties caused by background concentrations;
- specific testing equipment (sampling equipment, analyser).

6 Statistical evaluation

6.1 Calculation of the mean

After discarding any doubtful results, the series comprises n measurements x_i (where $i = 1, 2, 3, \ldots, n$), some of which can have the same value.

The mean of the underlying normal distribution is calculated by the arithmetic mean $\bar{x}$ of the n results:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (6)$$

6.2 Confidence interval for the mean

The confidence interval for the population mean is calculated from the values of the mean and of the standard deviation.

The standard deviation is calculated as follows:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (7)$$

where

x_i is the value of the i-th measurement ($i = 1, 2, 3, \ldots, n$);

n is the total number of measurements;

$\bar{x}$ is the arithmetic mean of the n measurements, calculated as in 6.1.

Bibliography

[1] ISO 3966, *Measurement of fluid flow in closed conduits — Velocity area method using Pitot static tubes*

[2] ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

[3] ISO 5168, *Measurement of fluid flow — Procedures for the evaluation of uncertainties*

[4] ISO 14123-2, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 2: Methodology leading to verification procedures*

[5] ISO 29042-4:—[1)], *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) To be published.

ICS 13.110

Price based on 8 pages