BRITISH STANDARD

BS EN 1093-1:2008

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

Part 1: Selection of test methods

ICS 13.040.40

British Standards

National foreword

This British Standard is the UK implementation of EN 1093-1:2008. It supersedes BS EN 1093-1:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/3, Safeguarding of machinery.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Sicherheit von Maschinen - Bewertung der Emission von luftgetragenen Gefahrstoffen - Teil 1: Auswahl der Prüfverfahren

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Foreword

This document (EN 1093-1:2008) 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of an identical text or by endorsement, at the latest by June 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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

This document supersedes EN 1093-1:1998.

For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document.

This part 1 of EN 1093 *Safety of machinery - Evaluation of the emission of airborne hazardous substances* belongs to a series of documents, the other parts of which are the following:

— 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: Capture efficiency of an exhaust system, tracer method;

— Part 6: Separation efficiency by mass, unducted outlet;

— Part 7: Separation efficiency by mass, ducted outlet;

— Part 8: Pollutant concentration parameter, test bench method;

— Part 9: Pollutant concentration parameter, room method;

— Part 11: Decontamination index.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

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

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

— **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);

— **Type-C standards** (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This European Standard is a type-B standard as stated in EN ISO 12100-1.

The provisions of this European Standard 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 provisions of that standard, the provisions of that type-C standard take precedence over the provisions of this type-B standard.

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

— 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;

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

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

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

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

This European 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 European Standard leads to an evaluation of the performance of the machine and its associated pollutant control system.

This European Standard can be used as a part of verification described in EN 626-2.

1 Scope

This European Standard 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 machines including the effects of measures to reduce exposures to pollutants. The test methods are given in additional parts of this European Standard (see Table 1 and Annex A).

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.

EN 626-2, *Safety of machinery – Reduction of risks to health from hazardous substances emitted by machinery – Part 2: Methodology leading to verification procedures*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 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 flow rate of tracer collected by exhaust system during operation;

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

NOTE 3 For further details, see EN 1093-4:1996+A1:2008, 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 percentage, 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 are possibly not 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:

$$I_A = \frac{1}{n}\sum_{i=1}^{n} \frac{C_{ai} - C_{mi}}{C_{ai} - C_{fi}} \quad (4)$$

where

C_{ai} real pollutant concentration measured at specified location in the surrounding under the following condition: machine in operation, pollutant control system not in operation;

C_{mi} real pollutant concentration measured at specified location in the surrounding under the following condition: machine and pollutant control system in operation;

C_{fi} real pollutant concentration measured at specified location in the surrounding under the following condition: machine and pollutant control system not in operation ("the background level");

n number of specified locations

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

$$I_A = 1 - \frac{1}{n}\sum_{i=1}^{n} \frac{C_{mi}}{C_{ai}} \quad (5)$$

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:

- nature of pollutant used;
- nature of the test environment.

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:

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

— 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 different parts of this European Standard.

Each identified method is described in detail in the part of this European Standard 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

<table>
<tr><th colspan="2" rowspan="2">Assessment parameters</th><th rowspan="2">Nature of pollutant</th><th colspan="3">Chosen method</th></tr>
<tr><th>Test bench method</th><th>Room method</th><th>Field method</th></tr>
<tr><td rowspan="3">Emission</td><td rowspan="2">Emission rate</td><td>Tracer and pollutant</td><td>–</td><td colspan="2">EN 1093-2</td></tr>
<tr><td>Pollutant</td><td>EN 1093-3</td><td>–</td><td>–</td></tr>
<tr><td>Pollutant concentration</td><td>Pollutant</td><td>EN 1093-8</td><td>EN 1093-9</td><td>–</td></tr>
<tr><td rowspan="3">Capture</td><td rowspan="2">Efficiency</td><td>Tracer</td><td colspan="3">EN 1093-4</td></tr>
<tr><td>Pollutant</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Decontamination index</td><td>Pollutant</td><td>–</td><td colspan="2">EN 1093-11</td></tr>
<tr><td>Separation</td><td>Efficiency</td><td>Pollutant</td><td>EN 1093-6 and EN 1093-7</td><td>–</td><td>–</td></tr>
</table>

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) 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:

— controlled emission rate of this given pollutant ($\dot{m}_k$),

or indicated by:

— 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 pollutant control system of a given machine and without air recirculation, 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:

— uncontrolled emission rate of a given pollutant ($\dot{m}_u$);

— capture efficiency (η_c);

— 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 consideration such as:

— size of the machine;

NOTE 1 When a test chamber is to be used, a maximum cross-sectional area of the machine equal to a fifth of the cross section area of the test chamber is recommended.

— ease of handling of the machine;

— ease of installing, including its pollutant control system;

— ease of operation;

— nature of pollutant: toxicity and complexity of concentration measurement.

NOTE 2 Some of these difficulties can be overcome by using a tracer method.

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, analyzer).

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, …, n), some of which can have the same value.

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

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

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:

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

where

x_i value of the i-th measurement (i = 1, 2, 3, …, n);

n total number of measurements;

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

Annex A
(informative)

Standards suitable for the measurement of fluid flow rates

EN 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 (ISO 5167-1:2003).*

ISO 5168, *Measurement of fluid flow – Procedures for the evaluation of uncertainties*

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive Machinery 98/37/EC, amended by 98/79/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 98/37/EC

Clause(s)/subclause(s) of this EN	Essential Requirements (ERs) of Directive 98/37/EC, amended by 98/79/EC	Qualifying remarks/Notes
All clauses	Annex I, 1.5.13	Emission of dust, gases, etc.

WARNING — Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this standard.

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive Machinery 2006/42/EC.

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Table ZB.1 — Correspondence between this European Standard and Directive 2006/42/EC

Clause(s)/subclause(s) of this EN	Essential Requirements (ERs) of Directive 2006/42/EC	Qualifying remarks/Notes
All clauses	Annex I, 1.5.13	Emissions of hazardous substances and materials

WARNING — Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 1093-2, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 2: Tracer gas method for the measurement of the emission rate of a given pollutant*

[2] EN 1093-3, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 3: Test bench method for the measurement of the emission rate of a given pollutant*

[3] EN 1093-6, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 6: Separation efficiency by mass, unducted outlet*

[4] EN 1093-7, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 7: Separation efficiency by mass, ducted outlet*

[5] EN 1093-8, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 8: Pollutant concentration parameter, test bench method*

[6] EN 1093-9, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 9: Pollutant concentration parameter, room method*

[7] EN 1093-11, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 11: Decontamination index*

[8] EN 1093-4:1996+A1:2008, *Safety of machinery – Evaluation of the emission of airborne hazardous substances – Part 4: Capture efficiency of an exhaust system – Tracer method*

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