BS EN 15051-3:2013

BSI Standards Publication

Workplace exposure — Measurement of the dustiness of bulk materials

Part 3: Continuous drop method

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National foreword

This British Standard is the UK implementation of EN 15051-3:2013. Together with BS EN 15051-1:2013 and BS EN 15051-2:2013 it supersedes BS EN 15051:2006, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/2/2, Work place atmospheres.

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

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Exposition sur les lieux de travail - Mesure du pouvoir de resuspension des matériaux pulvérulents en vrac - Partie 3: Méthode de la chute continue

Exposition am Arbeitsplatz - Messung des Staubungsverhaltens von Schüttgütern - Teil 3: Verfahren mit kontinuierlichem Fall

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Foreword

This document (EN 15051-3:2013) has been prepared by Technical Committee CEN/TC 137 “Assessment of workplace exposure to chemical and biological agents”, 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of an identical text or by endorsement, at the latest by May 2014, and conflicting national standards shall be withdrawn at the latest by May 2014.

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, together with EN 15051-1:2013 and EN 15051-2:2013, supersedes EN 15051:2006.

The major technical changes between this European Standard and the previous edition are as follows:

a) EN 15051:2006 has been split into three parts (see below);

b) the test methods given are no longer referred as reference test methods;

c) the test of equivalence between an alternative (candidate) test method and any of the test methods now given in EN 15051-2 and this European Standard have been deleted.

EN 15051 *Workplace exposure – Measurement of the dustiness of bulk materials* consists of the following parts:

— *Part 1: Requirements and choice of test methods;*

— *Part 2: Rotating drum method;*

— *Part 3: Continuous drop method.*

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, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard gives details of the design and operation of the continuous drop test method that classifies the dustiness of solid bulk materials, in terms of health-related fractions.

A dustiness classification is presented to provide users (e.g. manufacturers, producers, occupational hygienists and workers) with information on the potential for dust emissions when the bulk material is handled or processed in workplaces. It provides the manufacturers of bulk materials with information that can help to improve their products. It allows the users of the bulk materials to assess the effects of pre-treatments, and also to select less dusty products, if available. It is envisaged that different branches of industry might develop their own classification schemes using experimentally determined dustiness values of the bulk materials of interest.

Although this European Standard does not discuss the analysis of dust released from bulk materials (except in terms of health-related fractions), the test method produces samples with the potential for chemical analysis of the contents.

This European Standard was developed based on the results of the European project SMT4-CT96-2074 “Development of a Method for Dustiness Testing” (see [1]). This project investigated the dustiness of 12 bulk materials, with the intention to test as wide a range of bulk materials as possible, i.e. magnitude of dustiness, industrial sectors, chemical composition and particle size distribution. Meanwhile the method has been applied to investigate the dustiness of more than 500 different bulk materials (see [2]).

1 Scope

This European Standard specifies the continuous drop test apparatus and associated test method for the reproducible production of dust from a bulk material under standard conditions, and the measurement of the inhalable and respirable fractions of this dust, with reference to existing European Standards, where relevant (see Clause 6).

The continuous drop method intends to simulate dust generation processes where there are continuous falling operations (conveying, discharging, filling, refilling, weighing, sacking, metering, loading, unloading etc.) and where dust is liberated by winnowing during falling. It can be modified to measure the thoracic fraction as well, but this modification is not described in this European Standard. It differs from the rotating drum method presented in EN 15051-2 in that in this European Standard, the bulk material is dropped only once, but continuously, while in EN 15051-2, the same bulk material is repeatedly dropped.

Furthermore, this European Standard specifies the environmental conditions, the sample handling and analytical procedures and the method of calculating and presenting the results. A classification scheme for dustiness is specified, to provide a standardised way to express and communicate the results to users of the bulk materials.

This European Standard is applicable to powdered, granular or pelletised bulk materials.

This European Standard is not applicable to test the dust released when solid bulk materials are mechanically treated (e.g. cut, crushed) or to evaluate handling procedures for the bulk materials.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1540, *Workplace exposure - Terminology*

prEN 13205-1, *Workplace exposure - Assessment of sampler performance for measurement of airborne particle concentrations - Part 1: General requirements*

EN 15051-1:2013, *Workplace exposure - Measurement of the dustiness of bulk materials - Part 1: Requirements and choice of test methods*

EN 22768-1, *General tolerances - Part 1: Tolerances for linear and angular dimensions without individual tolerance indications (ISO 2768-1)*

EN ISO 13137, *Workplace atmospheres - Pumps for personal sampling of chemical and biological agents - Requirements and test methods (ISO 13137)*

ISO 15767, *Workplace atmospheres - Controlling and characterizing uncertainty in weighing collected aerosols*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 1540 and EN 15051-1 apply.

NOTE In particular, the following terms of EN 1540 are used in this document: airborne dust, collected sample, dustiness, inhalable fraction, respirable fraction, thoracic fraction and health related fractions.

4 Requirements

4.1 General

The test procedures described in EN 15051-1:2013, Clause 5 shall be applied.

4.2 Condition of the bulk material

The bulk material shall be delivered in air-tight containers and shall be tested in the state in which it was received (moisture content, particle size distribution, etc.).

4.3 Sample and environmental control

Bulk materials that have a large specific surface area are sensitive to environmental conditions such as relative humidity, temperature and electrostatic effects. Additionally, the bulk materials' moisture content, compaction, agglomeration etc. will have an influence on the results of the dustiness measurements. Therefore, for accurate results the test atmosphere shall be within a narrow range of temperature and humidity. In all cases the environmental conditions shall be documented.

The following test conditions shall apply:

— relative humidity (RH): (50 ± 10) %;

— temperature: (21 ± 3) °C.

The test apparatus shall be electrically grounded.

A separate determination of the particle size will provide valuable information.

4.4 Moisture content

The moisture content of the bulk material shall be determined and documented according to the procedure given in EN 15051-1:2013, 5.4 and Annex A.

4.5 Bulk density

The bulk density of the test material shall be determined and documented according to the procedure given in EN 15051-1:2013, Annex B.

4.6 Test procedure

The dustiness shall be tested according to the continuous drop test method described in Clause 5.

4.7 Replicate tests

Replicate tests shall be carried out according to 5.6.

4.8 Reporting

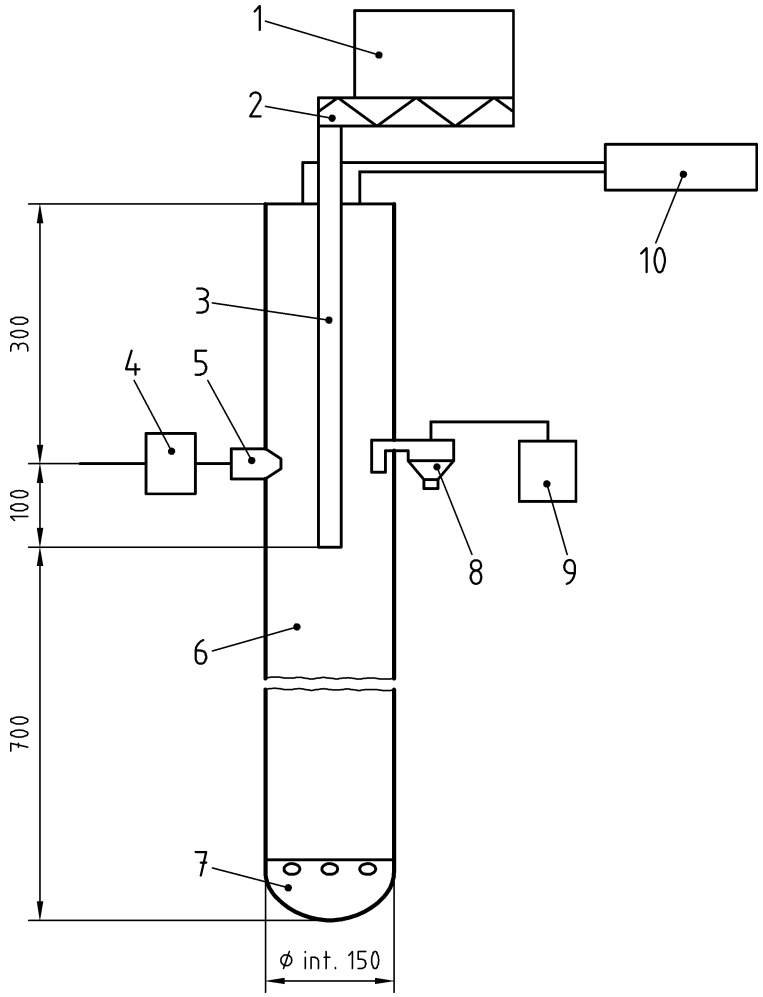
The test results shall be reported as specified in Clause 7.

5 Continuous drop method

5.1 Description of test apparatus

The test apparatus required to determine the dustiness of bulk materials is shown in Figure 1.

Dimensions in millimetres



Key

1 sample tank
2 metering device
3 drop pipe
4 pump for sampling the inhalable fraction of aerosol
5 sampler for the inhalable fraction of aerosol
6 backflow pipe
7 collector tank
8 sampler for the respirable fraction of aerosol
9 pump for sampling the respirable fraction of aerosol
10 main flow pump

General tolerances according to EN 22768-1

Figure 1 — Outline of the continuous drop test apparatus

The sample tank (1) shall be large enough to hold the entire mass of the test substance for all the intended test runs. It shall be made of inert material, preferably stainless steel.

The type of metering device (2) is not regulated. The metering device shall not change the composition and properties of the test material and be suited for mass flows in the intended range of 6 g · min^{-1} to 10 g · min^{-1}.

EXAMPLE Examples of successfully tested metering devices are metering screws and vibrating ducts.

The drop pipe (3) is a thin-walled tube with an inner diameter in the range from 16 mm to 25 mm. The drop pipe is preferably made from stainless steel.

The backflow pipe (6) is round with an inner diameter of 150 mm. It shall be manufactured from an inert and electrically conducting material, preferably stainless steel. Within the backflow pipe a vertical air speed of 0,050 m s^{-1} shall be generated. Small parts of the tube may be made of transparent material, for example glass, in order to allow visible control of the experiments.

The reference values for the airflows of the main flow pump (10), the pump for sampling the respirable fraction of aerosol (9) and the pump for sampling the inhalable fraction of aerosol (4) are 49 l · min^{-1} and 2 l · min^{-1}, respectively. The reference value for the airflow in the back flow pipe is 53 l · min^{-1}. The reference flow for the samplers is 2 l · min^{-1}.

These conditions may be changed within narrow limits as long as

— the air speed within the pipe is (0,050 ± 0,002 5) m · s^{-1} (i.e. a total airflow of 53 l · min^{-1}), and

— no sampling airflow exceeds 3,5 l · min^{-1}.

The sampling of the inhalable and the respirable fraction of aerosol shall comply with prEN 13205-1, and the respective pumps shall comply with EN ISO 13137.

The collector tank (7) shall be mounted to the backflow pipe (6). It is used to collect the dropped mass and shall therefore be suited for weighing. In addition, the external air which generates the upstream airflow within the backflow pipe (6) needs to pass through the collector tank.

NOTE Filter cups have been used successfully as a collector tank.

5.2 Filters

Filters with diameters of 37 mm can be used to collect the sampled aerosol fractions. If additional analytical investigations are intended for the sampled respirable and inhalable dust, a selection of suitable filter materials is necessary.

To prevent overloading of the filter for the inhalable fraction, filter thimbles (10 mm × 50 mm) which have been demonstrated to give identical results should be used.

5.3 Ancillary equipment

For weighing the dropped mass in the collector tank and the sampled masses of the respirable and inhalable fraction the following weighing equipment shall be used:

— an analytical balance capable of weighing the collector cup, including collected bulk material, to a resolution of 0,1 g;

— a suitable analytical balance capable of weighing the filter samples to a resolution of 0,01 mg.

5.4 Preparation of test sample

The necessary minimum amount of sample material to be filled into the sample tank is obtained from the drop mass flow (6 g · min^{-1} to 10 g · min^{-1}), the measurement period (usually 10 min), and five tests. Normally at least 500 g of sample material is required.

Test samples shall be extracted from the bulk material using a method, which will result in representative sampling (for example, BS 3406-1 or DIN 51701-3, see [4] and [5]).

If during replicate tests a monotonic increase/decrease of the measured dustiness mass fractions is observed, this is a strong indication that the bulk material could be prone to segregation effects while being mechanically treated. In these cases, the replicate tests (see 5.6) shall be performed using freshly obtained samples extracted from the bulk material for each replicate test. This modification of the test procedure should be mentioned in the test report.

5.5 Preparation of test apparatus

Before carrying out the measurements on the sample, the backflow pipe, the collector tank, the samplers and also the main flow pump protective filter shall be carefully cleaned.

Before performing the actual test runs the drop mass flow shall be adjusted to the desired rate. This preliminary activity can be considered as a conditioning step for the test apparatus.

The test apparatus shall neither be cleaned (as described above) between the single test runs nor between the conditioning run and the first test run.

5.6 Test procedure

Load the sample material to the sample tank in the as-delivered state without dust loss, if necessary with the aid of a spoon or spatula, so that the top level of the bulk sample in the sample tank during all experiments is always above the entrance to the metering device.

Set the dispensing speed of the metering device by weighing (repeatedly, if necessary) the dropped mass so that a drop mass flow in the range from 6 $g \cdot min^{-1}$ to 10 $g \cdot min^{-1}$ is achieved. Fit the samplers with filters pre-weighed by means of an analytical balance. Weigh the cleaned collector tank and secure in place.

NOTE Filters can be plane filters, like those used in workplace air sampling, or preferably, filter thimbles with higher storage capacity (see 5.1).

Start the measuring units by using the following starting sequence:

— main flow pump;

— respirable dust pump;

— inhalable dust pump;

— metering device.

Start the measurement by turning on the metering device.

At the end of the measurement, normally after 10 min operation time, switch off the measuring units simultaneously.

Remove, weigh and empty the filled collector tank. Remove the loaded respirable dust and inhalable dust filters or filter thimbles from the samplers and weigh using an analytical balance.

Repeat the complete test procedure four times.

5.7 Weighing the filters

Weighing of the filters or filter thimbles shall be done in accordance with ISO 15767.

5.8 Determination of the inhalable and respirable dustiness mass fractions

The inhalable and respirable dustiness mass fractions $w_{I,B}$ and $w_{R,B}$, in milligrams per kilogram, are calculated for each single test according to the Formulae (1) and (2), whereas the total flow rate is calculated according to Formula (3).

$$w_{I,B} = \frac{\Delta m_I}{m_c} \cdot \frac{Q_{tot}}{Q_I} \quad (1)$$

$$w_{R,B} = \frac{\Delta m_R}{m_c} \cdot \frac{Q_{tot}}{Q_R} \quad (2)$$

$$Q_{tot} = Q_R + Q_I + Q_m \quad (3)$$

where

Δm_I is the mass of the dust collected by the sampler for inhalable dust, in milligrams (mg);

Δm_R is the mass of the dust collected by the sampler for respirable dust, in milligrams (mg);

m_c is the drop mass in the collector tank, in kilograms (kg);

Q_{tot} is the total flow rate, in litres per minute ($l \cdot min^{-1}$);

Q_I is the flow rate of the sampler for inhalable dust, in litres per minute ($l \cdot min^{-1}$);

Q_R is the flow rate of the sampler for respirable dust, in litres per minute ($l \cdot min^{-1}$);

Q_m is the main pump flow rate, in litres per minute ($l \cdot min^{-1}$).

For each dustiness mass fraction, calculate the mean and the relative standard deviation. These values shall be stated in the test report. The mean of each dustiness mass fraction is used for the dustiness classification in Clause 6.

NOTE In order to be exactly correct, Formulae (1) and (2) assume isokinetic sampling of the respirable and inhalable fractions. This will not be the case for all possible sampling flow rates applied within the scope of this European Standard. This is a deliberate design decision in order to define dustiness mass fraction values approximately independent of the sampling flow rate under sampling conditions.

6 Evaluation of dustiness

The measured values of inhalable or respirable dustiness mass fractions of different bulk materials can be used

a) to classify bulk materials according to their propensity to emit dust and thus aid occupational hygienists and process engineers to assess and control the health risk of airborne dust,

b) to optimize some technical properties of bulk materials.

If a classification of the dustiness of the tested bulk materials is required, it shall be done according to one of four categories, i.e. “very low”, “low”, “moderate” or “high”, on the basis of the dustiness mass fractions in each health-related fraction measured. The classification scheme for the continuous drop method is given in Table 1. The scheme is based on the results of more than 500 different bulk materials that have been investigated to this day. The classification limits correspond to the quartiles of those results.

NOTE Alternative classification schemes are possible, see Introduction.

Table 1 — Dustiness classification for the continuous drop method

Category of dustiness	Inhalable dustiness mass fraction, $w_{I,B}$ mg/kg	Respirable dustiness mass fraction, $w_{R,B}$ mg/kg
Very low	< 1 000	< 20
Low	1 000 to 4 000	20 to 70
Moderate	> 4 000 to 15 000	> 70 to 300
High	> 15 000	> 300

7 Test report

The test report shall contain at least the following information:

a) a reference to this European Standard;

b) reference to modification of the test scheme according to 5.4, if applicable;

c) identification of the test laboratory and test personnel;

d) identification of contractor, if applicable;

e) date of testing;

f) batch identification of the bulk material tested;

g) mass of each sample, in grams;

h) moisture content of the bulk material, as mass ratio in per cent (%), with specification of analytical method used;

i) bulk material density, in kilograms per cubic metre ($kg \cdot m^{-3}$), with specification of analytical method used;

j) size distribution of the bulk material, if measured, with specification of the analytical method used;

k) environmental conditions including relative humidity, in per cent (%), and temperature, in degree Celsius (°C), at the time of testing;

l) dustiness mass fractions ($w_{I,B}$ $w_{R,B}$,), in milligrams per kilogram ($mg \cdot kg^{-1}$) for each replicate test, plus mean and relative standard deviation of all test results;

m) inhalable and respirable dustiness classification for the bulk material according to Table 1.

Bibliography

[1] BURDETT. G., *Development of a method for dustiness testing – Final report of EU contract SMT4-CT96-2074*, HSE Report IR/L/M/00/11, Health and Safety Laboratory, Sheffield, UK, 2000

[2] MÖCKLINGHOFF, K. & DAHMANN, D., *Dustiness measurements with a continuous drop pipe* (in preparation)

[3] EN 15051-2, *Workplace exposure — Measurement of the dustiness of bulk materials — Part 2: Rotating drum method*

[4] BS 3406-1, *Methods for determination of particle size distribution — Guide to powder sampling*

[5] DIN 51701-3, *Prüfung fester Brennstoffe — Probenahme und Probenvorbereitung — Durchführung der Probenvorbereitung*

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