BS EN 15051-1:2013

BSI Standards Publication

Workplace exposure — Measurement of the dustiness of bulk materials

Part 1: Requirements and choice of test methods

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National foreword

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 Together with BS EN 15051-2:2013 and BS EN 15051-3:2013 it supersedes BS EN 15051:2006, which is withdrawn.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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Exposition am Arbeitsplatz - Messung des Staubungsverhaltens von Schüttgütern - Teil 1: Anforderungen und Auswahl der Prüfverfahren

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Foreword

This document (EN 15051-1:2013) 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of an identical text or by endorsement, at the latest by May 2014, and conflicting national standards shall be withdrawn at the latest by May 2014.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 15051-2:2013 and EN 15051-3:2013, 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 in three parts (see below);

b) the test methods given are no longer referred to 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 EN 15051-3 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.*

EN 15051-2 and EN 15051-3 give details of two test apparatus and test methods for the reproducible production of dust from a bulk material under standard conditions, and the measurement of the inhalable, thoracic and respirable fractions of this dust, with reference to the existing European Standards, where relevant (see Clause 6).

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

The control of dust emissions during the handling and transportation of bulk materials is an important consideration in the design and operation of many industrial processes. Excessive airborne dust levels in workplaces are undesirable for several reasons:

— they can cause adverse health effects to the workers;

— their control can involve the use of costly ventilation and filtration systems;

— they can contaminate machinery and products;

— they can be costly in terms of product losses;

It is therefore advantageous for occupational hygienists and process engineers to have relevant information about the propensity of bulk materials to produce airborne dust (the "dustiness" of the bulk material) so that risks can be evaluated, controlled and minimized.

No single method of dustiness testing is likely to represent and reproduce the various types of processing and handling used in industry. Therefore a number of dustiness testing methods are in use in different industries. Different methods use different test apparatus and measuring principles, and express results in different ways. Methods that do not separate the dust cloud produced into the three health-related size fractions - inhalable, thoracic and respirable dust - can serve the needs of manufacturing industry for process and batch control, but give limited information on the health hazard due to the dustiness of the bulk material.

Dustiness is a relative term and the measurement obtained will depend on the test apparatus used, the condition and properties of the tested bulk material and various environmental variables. The test and the variables therefore need to be closely specified to ensure reproducibility. Recognising the above, it was concluded that there was a need for standardized methods to measure the dustiness of bulk materials, based on the biologically relevant aerosol fractions defined in EN 481.

This European Standard, together with EN 15051-2 and EN 15051-3, establishes test methods that classify the dustiness, in terms of health-related fractions, of solid bulk materials. The dustiness classification is intended 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. 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.

If methods to evaluate dustiness for bulk materials handled in other ways are deemed of importance, CEN/TC 137 could be approached for adopting a new work item, e.g. more specific industrial handling procedures.

The level of the dustiness generally depends on material-specific and process-specific parameters. The most important material-specific parameters are

— the particle size distribution of the bulk material,

— its bulk density,

— its moisture content ("bulk material moisture content"),

— its chemical composition,

— physical characteristics like electrostatic charge distribution.

Process-specific parameters are mainly determined by the type of handling and are essentially determined by

— the type and level of energy that leads to dust release, and

— the duration of the energy effect.

This European Standard was originally 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. In this revised version, important comments from industrial users of the standard (e.g. Industrial Minerals Association), a number of research papers (for example, [2] and [3]) and the potential influence of the expanding database of dustiness results have been taken into account.

1 Scope

This European Standard specifies the environmental conditions, the sample handling and analytical procedures and the method of calculating and presenting the results. Reasons are given for the need for more than one method and advice is given on the choice of method to be used.

This European Standard establishes a classification scheme for dustiness to provide a standardised way to express and communicate the results to users of the bulk materials. Details of the scheme for each method are given in EN 15051-2 and EN 15051-3.

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

This European Standard is not applicable to test the dust released during mechanical reduction of solid bulk materials (e.g. cut, crushed) or to test application procedures for the bulk materials.

Figure 1 gives a flow chart to provide the user of this European Standard a route through the necessary stages that need to be taken to obtain values of the dustiness of a given bulk material.

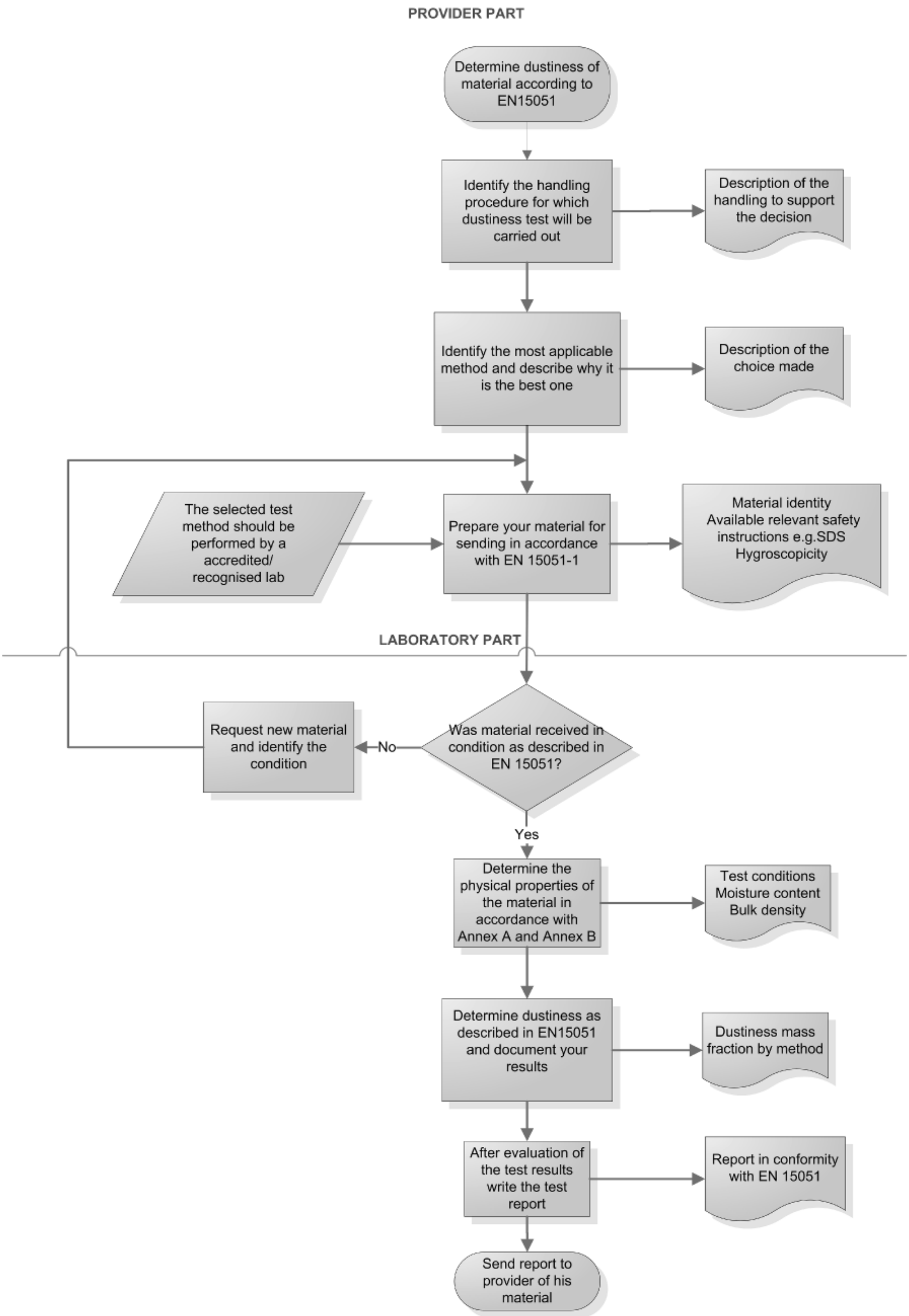

Figure 1 — Flow chart to show how EN 15051 is used to measure the dustiness of a bulk material

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*

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

EN 15051-3, *Workplace exposure - Measurement of the dustiness of bulk materials - Part 3: Continuous drop method*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 1540 and the following 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.

3.1
inhalable dustiness mass fraction
$w_{\mathrm{I},t}$
ratio of the inhalable dust produced by the dustiness test procedure, to the test mass for the respective test method *t*

Note 1 to entry: The different test methods are described in EN 15051–2 and EN 15051–3, and *t* has the value A and B for the two methods respectively.

3.2
respirable dustiness mass fraction
$w_{\mathrm{R},t}$
ratio of the respirable dust produced by the dustiness test procedure to the test mass for the respective test method *t*

Note 1 to entry: The different test methods are described in EN 15051–2 and EN 15051–3, and *t* has the value A and B for the two methods respectively.

3.3
thoracic dustiness mass fraction
$w_{\mathrm{T},t}$
ratio of the thoracic dust produced by the dustiness test procedure to the initial mass for the respective test method *t*

Note 1 to entry: The different test methods are described in EN 15051–2 and EN 15051–3, and *t* has the value A and B for the two methods respectively.

4 Principle

A dustiness tester consists of the following elements:

— dust generation section;

— dust transfer section;

— sampling section;

— size fractionator(s);

— dust collection section.

A standard volume of bulk material, with known moisture content and bulk density, is weighed and then placed in the dust generation section, where it is treated under standard conditions for a set period of time. The airborne dust released is drawn from the dust generation section, through the dust transfer section, into the sampling section. Here, the size fractionator(s) classifies the airborne dust according to aerodynamic particle size. The dust collection section deposits the dust fractions onto suitable media for gravimetric analysis. The results are used to calculate the inhalable, thoracic and respirable dustiness mass fractions of the released dust, in relation to the initial mass of bulk material used. These data are used to classify the dustiness of the bulk material.

5 General procedures

5.1 Condition of the bulk material

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

5.2 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, and to their own moisture content, compaction and agglomeration. 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.

NOTE In many cases, a separate determination of the particle size can be valuable.

5.3 Taking samples from the bulk material

It is important to ensure that the samples of the bulk material taken for dustiness measurement are as representative as possible of the bulk material supplied. Settlement of the larger particles in the container during transport can mean that the particle size distribution varies significantly in different parts of the container. There are a number of standard methods for taking samples from bulk powders (for example, BS 3406-1, DIN 51703-3, see [5] and [6]), including mixing up the bulk material and using devices such as rifflers to take representative samples, or processes called quartering. However, in all these methods, the bulk material is handled, potentially putting it under mechanical stress, and exposing it to ambient air, such that the particle size and/or moisture content can change, leading to a change in dustiness.

In practice, therefore simpler methods shall be used and their details shall be documented. The recommended method is as follows: For each replicate sample, the container with the bulk material (as supplied by the customer) shall be inverted a number of times and a sample taken out of top of the container and the container sealed. Make sure that there is enough free space in the container before the turning to make sure that the mixing is complete. This shall be repeated at least five times, or as many times as the number of replicate samples that are required. In this way, the set of samples taken can be regarded as representative of the characteristics of the bulk material. The validity of using this simple method is shown by the distribution of the dustiness results. If they show a steady increase or decrease, rather than a random scattering, then another standardized method shall be used (for example, BS 3406-1 or DIN 51701-3, see [5] and [6]) and documented.

It can be necessary to take subsamples from a large amount of bulk material, for example from large sacks, delivered for testing.

It is the responsibility of the laboratory carrying out the dustiness measurements to ensure that the sampling method used gives samples that have properties representative of the bulk material.

5.4 Moisture content

The moisture content of the bulk material shall be determined and documented according to the procedure given in Annex A. This can either involve the use of an infrared dryer (see A.1), or for those laboratories that do not have an infrared dryer, the alternative method may be used (see A.2).

5.5 Bulk density

The bulk density of the test material shall be determined and documented according to the procedure given in Annex B.

5.6 Test procedure

The dustiness shall be tested according to one of the test methods described in Clause 6 and EN 15051-2 and EN 15051-3 respectively. The choice of test method shall be justified in the test report (see Clause 8).

5.7 Replicate tests

Replicate tests shall be carried out according to the specific test methods in EN 15051-2 and EN 15051-3 respectively.

5.8 Reporting

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

6 Choice of test methods

6.1 General

Two test methods are proposed.

It is the responsibility of the providers of the bulk material to select the most appropriate test method for their application, though the selected test method cannot be considered to produce dustiness values that directly approximate what would be expected in the intended application.

1) Rotating drum method

   The rotating drum method involves the continuous multiple dropping of a sample of the bulk material in a slow horizontal winnowing current of air. The dust released from dropping bulk material is conducted by the airflow to a sampling section where it is separated aerodynamically into the three health-related fractions by a process of horizontal elutriation and inertial impaction in two stages of porous metal foam.

   The standard test apparatus and method is described in EN 15051-2.

2) Continuous drop method

The continuous drop method involves the continuous dropping of bulk material in a slow vertical air current. The dust released from dropping bulk material is conducted by the airflow to a sampling section where it is separated aerodynamically into the inhalable and respirable fractions.

The standard test apparatus and method is described in EN 15051-3.

6.2 Selection of the most appropriate test method

Both test methods are intended to simulate handling processes, which involve dropping processes of powdery bulk material at some stage. The two test methods differ however with respect to the intensity and the duration of treatment of the bulk material. In addition, the rotating drum method drops the bulk materials a number of times, whilst the continuous drop method drops the bulk material once (see EN 15051-2 and EN 15051-3). This is intentional, as in practice the dust-creating processes in the workplace will also have different characteristics. In a few cases the two test methods will give different results. Examples of this are bulk materials that can agglomerate and bulk materials that comprise brittle powder structures that can break after prolonged handling, for example sulphur gives totally different results when tested by the two methods because of the agglomeration of the particles when dropped many times. Because of these effects, users of this European Standard shall choose the test method for the measurement of the dustiness most appropriate to their bulk material and handling process, and shall state this chosen test method in their test report. It is to be remembered that it is not expected that the two methods will necessarily give the same results for a given bulk material.

In order to ensure the quality of the results obtained when measuring the dustiness of bulk materials using the methods described above, laboratories should participate in a suitable proficiency testing scheme to be set up for these test methods.

7 Evaluation of dustiness

The measured values of inhalable, thoracic 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 evaluate and control the health risk of airborne dust;

b) to produce less dusty bulk materials;

c) to use the relative dustiness values to lower dust exposure while using these bulk materials in specific industrial sectors (e.g. construction chemicals or industrial minerals).

If it is required to compare the dustiness of the bulk material with those from other bulk materials then a general classification scheme can be used. In this European Standard, the dustiness of the bulk material shall be classified into one of the four categories “very low”, “low”, “moderate” or “high”, on the basis of the dustiness mass fractions in each health-related fraction. The classification shall be according to the appropriate scheme for the test method used. The classification schemes for the two test methods, rotating drum method and continuous drop method, are given in EN 15051-2 and EN 15051-3, respectively.

The dustiness classification for those dust fractions measured shall be communicated as stated in the following example:

— dustiness according to EN 15051-2 (or EN 15051-3): Inhalable fraction – Low (give value in mg/kg);

— dustiness according to EN 15051-2: Thoracic fraction – Low (give value in mg/kg);

— dustiness according to EN 15051-2 (or EN 15051-3): Respirable fraction – Moderate (give value in mg/kg).

8 Test report

The test report shall contain at least the following information:

a) a reference to this European Standard;

b) identification of test house and test personnel;

c) identification of contractor, if applicable;

d) date of testing;

e) reference to EN 15051-2 and EN 15051-3 to specify the test method that was used;

f) batch identification of the bulk material tested;

g) volume of samples taken from the bulk material, in cubic centimetres (cm^3);

h) mass of each sample, in grams (g);

i) moisture content of the bulk material in per cent (%), with specification of analytical method;

j) bulk density in kilograms per cubic metres (kg/m^3), with specification of analytical method;

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

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

m) dustiness mass fractions ($w_{\mathrm{I},t}$, $w_{\mathrm{T},t}$, $w_{\mathrm{R},t}$), depending on the test method used, in milligrams per kilogram (mg/kg) for each replicate test, plus the mean and the standard deviation of all test results;

n) inhalable, thoracic and respirable dustiness classification for the bulk material.

Annex A
(normative)

Determination of moisture content

A.1 Infrared dryer method

A.1.1 Principle

The principle of operation of this method is the automatic weighing of a bulk material sample while infrared radiation is applied. The weight is read every 30 s. The reading shall be stopped at a predetermined weight loss rate or a predetermined time. As there are various infrared dryers commercially available only the general requirements for the application are given.

A.1.2 Procedure

Put the bulk material into the holding vessel of the device using the amount (a minimum of 10 g) indicated by the manufacturer. Determine and record a starting mass for the experiment.

The devices generally operate either until a predetermined mass loss per time period (e.g. 1 mg per 30 s) is reached or until a pre-selected duration (for example 1 h) is exceeded. In either case the total mass loss is determined according to Formula (A.1) and the moisture content according to Formula (A.2):

$$m_{\mathrm{S},i} = m_{\mathrm{Sb},i} - m_{\mathrm{Sa},i} \tag{A.1}$$

$$q_i = \frac{m_{\mathrm{S},i}}{m_{\mathrm{Sb},i}} \cdot 100 \tag{A.2}$$

where

$m_{\mathrm{S},i}$ is the loss of mass of the sample in holding vessel i, after oven treatment, in grams (g);

$m_{\mathrm{Sb},i}$ is the mass of the sample in holding vessel i before oven treatment, in grams (g);

$m_{\mathrm{Sa},i}$ is the mass of the sample in holding vessel i after oven treatment, in grams (g);

q_i is the moisture content of the sample in holding vessel i, calculated by the difference in mass of holding vessel i, before and after oven treatment, given as mass ratio in per cent (%).

Repeat this procedure three times and record the mean moisture content of the three experiments. Report it together with its standard deviation.

NOTE The duration of drying is highly dependent on the bulk material and can vary from a minimum of 3,5 min to 45 min. The reason for this is that it can be difficult to remove moisture out of the bulk material, or that the bulk material is highly hygroscopic and during measurement again absorbs moisture. The better the bulk material is spread out, the more rapid the mass becomes constant. It is recommended to adapt the adjustments of the balance accordingly.

A.2 Alternative method

Pre-weigh six identifiable glass Petri dishes after storage at weighing room conditions for 2 h. Weigh about 10 g of the bulk material as supplied, into three of the glass Petri dishes, and record the masses. Weigh to the nearest 0,1 mg (using a 4-decimal place analytical balance or better). Heat all six Petri dishes at 100 °C for at least 4 h then leave in a dessicator to cool for at least 30 min. Remove the Petri dishes from the dessicator in turn and reweigh, taking the analytical balance reading 30 s after removing from the dessicator, or when the analytical balance has stabilized.

The mean mass loss of the three control Petri dishes is used to correct the final mass of three sample Petri dishes. The loss of mass recorded for the bulk material is used to calculate the moisture content, in per cent, by Formulae (A.3) to (A.7):

$$m_{\mathrm{Sb},i} = m_{\mathrm{PSb},i} - m_{\mathrm{Pb},i} \tag{A.3}$$

$$m_{\mathrm{C},j} = m_{\mathrm{Pa},j} - m_{\mathrm{Pb},j} \tag{A.4}$$

$$\overline{m}_{\mathrm{C}} = \frac{m_{\mathrm{C,1}} + m_{\mathrm{C,2}} + m_{\mathrm{C,3}}}{3} \tag{A.5}$$

$$m_{\mathrm{Sa},i} = m_{\mathrm{PSa},i} - m_{\mathrm{Pb},i} - \overline{m}_{\mathrm{C}} \tag{A.6}$$

$$q_i = \frac{m_{\mathrm{Sb},i} - m_{\mathrm{Sa},i}}{m_{\mathrm{Sb},i}} \cdot 100 \tag{A.7}$$

where

$\overline{m}_{\mathrm{C}}$	is the mean mass change of the three control Petri dishes used, in grams (g);
$m_{\mathrm{C},j}$	is the mass change of the control Petri dish j, in grams (g);
$m_{\mathrm{Pb},j}$	is the mass of the control Petri dish j before oven treatment, in grams (g);
$m_{\mathrm{Pa},j}$	is the mass of the control Petri dish j after oven treatment, in grams (g);
$m_{\mathrm{Pb},i}$	is the mass of the Petri dish i without sample before oven treatment, in grams (g);
$m_{\mathrm{PSb},i}$	is the mass of the Petri dish i with sample before oven treatment, in grams (g);
$m_{\mathrm{PSa},i}$	is the mass of the Petri dish i with sample after oven treatment, in grams (g);
$m_{\mathrm{Sb},i}$	is the mass of the sample in Petri dish i before oven treatment, in grams (g);
$m_{\mathrm{Sa},i}$	is the mass of the sample in Petri dish i after oven treatment, in grams (g);
q_i	is the moisture content of the sample in Petri dish i, calculated by the difference in mass of Petri dish i, before and after oven treatment, given as mass ratio in per cent (%).

Report the mean and the standard deviation of moisture content for the three samples.

Other methods may be used, if it can be demonstrated that identical results can be obtained.

Annex B
(normative)

Determination of bulk density of the test material

B.1 Equipment

The following equipment is needed to determine the bulk density:

— measuring cylinder of known volume (e.g. 35 cm^3 or 100 cm^3), and

— analytical balance capable of weighing up to 500 g to a resolution of 0,01 g.

B.2 Special requirements

The bulk density of the test material shall be determined at the moisture content in which it was received at the laboratory, and without changing the size distribution of the bulk material.

B.3 Procedure

Place the measuring cylinder onto the analytical balance and tare the balance to zero. Pour a sample from the test material into the measuring cylinder using a suitable spoon until it is filled up. Control the volume by slight hitting of the vessel onto a soft table surface (wood, thick paper etc.) and gentle knocking at the side of it. If necessary, pour more test material into the vessel. Then determine the mass of the sample.

The bulk density ρ, given in kilograms per cubic metres ($kg \cdot m^{-3}$), is calculated according to Formula (B.1).

$$\rho = 1\,000 \cdot \frac{m}{V} \tag{B.1}$$

where

ρ	is the bulk density, in kilograms per cubic metres (kg/m^3);
m	is the mass of the sample, in grams (g);
V	is the volume of the sample, in cubic centimetres (cm^3).

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] BACH. S. & SCHMIDT, E., *Determining the dustiness of powders — A comparison of three measuring devices. Ann. Occup. Hyg.* 2008, **52** (8) pp. 717–725

[3] PENSIS, I. et al. *Comparative evaluation of the dustiness of industrial minerals according to European Standard EN 15051*, 2006. *Ann. Occup. Hyg.* 2009, ••• pp. 1–13

[4] EN 481, *Workplace atmospheres - Size fraction definitions for measurement of airborne particles*

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

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

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