SWEDISH STANDARDS INSTITUTE

SVENSK STANDARD
SS-EN 15051:2006

Fastställd 2006-05-05

Utgåva 1

Arbetsplatsluft – Bestämning av damningsbenägenhet hos bulkmaterial – Krav och provningsmetoder

Workplace atmospheres – Measurement of the dustiness of bulk materials – Requirements and reference test methods

ICS 13.040.30

Språk: engelska

Publicerad: juni 2006

Europastandarden EN 15051:2006 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av EN 15051:2006.

The European Standard EN 15051:2006 has the status of a Swedish Standard. This document contains the official English version of EN 15051:2006.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15051

April 2006

ICS 13.040.30

English Version

Workplace atmospheres - Measurement of the dustiness of bulk materials - Requirements and reference test methods

Atmosphère des lieux de travail - Mesure du pouvoir de resuspension des matériaux pulvérulents en vrac - Exigences et méthodes d'essai de référence

Arbeitsplatzatmosphäre - Messung des Staubungsverhaltens von Schüttgütern - Anforderungen und Referenzprüfverfahren

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Ref. No. EN 15051:2006: E

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Foreword

This document (EN 15051:2006) 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of an identical text or by endorsement, at the latest by October 2006, and conflicting national standards shall be withdrawn at the latest by October 2006.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, 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 United Kingdom.

Introduction

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

a) can cause adverse health effects to the work force;
b) control can involve the use of costly ventilation and filtration systems;
c) can be costly in terms of lost product;
d) can contaminate machinery and products.

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

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 material.

Dustiness is a relative term and the measurement obtained will depend on the test apparatus used, the properties of the dust 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 standardised reference methods to measure the dustiness of bulk materials, based on the biologically relevant aerosol fractions defined in EN 481.

This document establishes reference test methods that classify the dustiness, in terms of health-related fractions, of bulk solid 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 material is handled or processed in workplaces. It provides the manufacturers of materials with information that can help to improve their products. It allows the users of the materials to assess the effects of pre-treatments, and also to select less dusty products, if available. Although this document 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 document also provides reference test methods to which users of alternative test methods on dustiness can compare their own measurements. A standardised test of equivalence is used to test whether the alternative test method is capable of reproducing the dustiness classifications of the reference test methods, for a range of standardised test dusts. If the requirements for equivalence are satisfied the alternative test method can be used to classify the dustiness of bulk materials.

This document 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 materials, with the intention to test as wide a range of materials as possible, i.e. magnitude of dustiness, industrial sectors, chemical composition and particle size distribution.

1 Scope

This document specifies the two reference test apparatuses and reference 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 CEN standards, where relevant (see Clause 6).

This document specifies the environmental conditions, the sample handling and analysis 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.

In Annex D, a test method is described that enables dustiness information produced by test methods other than these two reference test methods to be related to that produced using these standard reference test methods.

This document is applicable to powdered, granular or pelletised materials. A standard sample volume is used.

This document is not applicable to test the dust released when solid materials are mechanically reduced (e.g. cut, crushed) or to test handling procedures for the materials.

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 1232, *Workplace atmospheres - Pumps for personal sampling of chemical agents - Requirements and test methods*

EN 13205, *Workplace atmospheres – Assessment of performance of instruments for measurement of airborne particle concentrations*

ISO 15767, *Workplace atmospheres – Controlling and characterizing errors in weighing collected aerosols*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
airborne dust
finely divided matter in solid form, dispersed in air

3.2
health-related fractions
inhalable, thoracic and respirable fractions of airborne dust

NOTE For definitions of the inhalable, thoracic and respirable fractions, see EN 481.

3.3
collected sample
airborne particles collected on the sampling media (e.g. filter, foam or impaction plate) for subsequent analysis

NOTE Sample deposits in other parts of the sampler such as inner walls are only included in the collected sample where the method description includes specific instructions for the recovery of such deposits.

3.4
dustiness
propensity of materials to produce airborne dust during handling

NOTE For the purposes of this document, dustiness is derived from the amount of dust emitted during a standard test procedure.

3.5
inhalable dustiness
dustiness classification of the inhalable fraction

NOTE Classification assigned according to the scheme described in Clause 7.

3.6
thoracic dustiness
dustiness classification of the thoracic fraction

NOTE Classification assigned according to the scheme described in Clause 7.

3.7
respirable dustiness
dustiness classification of the respirable fraction

NOTE Classification assigned according to the scheme described in Clause 7.

3.8
inhalable dustiness mass fraction
$w_{I,A}$, $w_{I,B}$
ratio of the inhalable dust produced by the dustiness test procedure, in milligrams, to the test mass of material used for the test, in kilograms

NOTE For reference test method A the value of the test mass equals the initial mass, and for reference test method B the value of the test mass equals the mass collected in the collector tank.

3.9
thoracic dustiness mass fraction
$w_{T,A}$
ratio of the thoracic dust produced by the dustiness test procedure, in milligrams, to the initial mass of material used for the test, in kilograms

3.10
respirable dustiness mass fraction
$w_{R,A}$, $w_{R,B}$
ratio of the respirable dust produced by the dustiness test procedure, in milligrams, to the test mass of material used for the test, in kilograms

NOTE For reference test method A the value of the test mass equals the initial mass, and for reference test method B the value of the test mass equals the mass collected in the collector tank.

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, 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 material used. These data are used to classify the dustiness of the material.

5 Requirements

5.1 Condition of the material

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

5.2 Sample and environmental control

Materials that have a large specific area are sensitive to ambient conditions such as relative humidity, temperature, electrostatic effects and to their own moisture content, compaction, agglomeration etc. Therefore for accurate results a system controlling the test atmosphere within a narrow range of temperature and humidity should be used. In all cases the environmental conditions shall be documented.

Test conditions:

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

— temperature: (21 ± 3) °C;

— The test apparatus should be electrically grounded.

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

5.3 Moisture content

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

5.4 Bulk density

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

5.5 Test procedure

The dustiness shall be tested according to one of the reference test methods described in Clause 6 and Annex A. The choice of reference test method shall be justified in the test report, see Clause 6.

Providing the requirements for equivalence are satisfied, the dustiness may be tested using an alternative test method (see Annex D).

5.6 Replication

Replicate tests shall be carried out according to the specific reference test methods A or B, see Clause 6.

5.7 Reporting

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

6 Reference test methods

6.1 General

Two reference test methods are given: Method A produces dust by a multiple continuous dropping process of the bulk material, whereas Method B produces dust by dropping the bulk material once under gravity. Both reference test methods are intended to simulate general handling processes, which involve dropping processes of powdery material at some stage. The two reference test methods differ however with respect to the intensity and the duration of treatment of the bulk material. See 6.2.1 and 6.3.1. This is intentional, as in practice the dust-creating processes in the workplace will also have different characteristics. In some few cases the two reference 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, see for example the data for sulphur in Tables D.1 and D.2. Because of these effects, users of this document should choose the reference test method for the measurement of the dustiness most appropriate to their material and handling process, and shall state this chosen reference test method in their test report.

6.2 Method A: Rotating drum method

6.2.1 General

The rotating drum method involves the continuous multiple dropping of a sample of the material in a slow horizontal winnowing current of air. The dust released from dropping 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 reference test apparatus is described in A.1.

6.2.2 Preparation of test sample

Test samples should be extracted from the bulk material using a method, which would result in representative sampling (see e.g. BS 3406-1 or DIN 51701-3). A minimum of six samples is prepared. Sample bottles able to be sealed should be used to minimise contamination of the atmosphere.

Test samples with a volume of about 35 cm^3 should be extracted and weighed to the nearest± 0,1 g.

6.2.3 Preparation of test apparatus

Prior to the tests being carried out, the rotating drum is cleaned thoroughly using a suitable vacuum cleaner, wiped with a damp cloth and allowed to dry. For material that sticks to the internal surfaces it can also be necessary to wash the surfaces with a solution of a detergent in water followed by thorough washing with water, or to clean with a suitable solvent (e.g. propanol). Assemble the inlet and outlet stages to appropriate ends of the drum. Switch on the pump and set the flow rate to 38 l min^{-1}. Turn off the pump.

The test apparatus shall only be cleaned as described in this clause before the first test run. Between the test runs, after the inlet and outlet stages have been removed, the apparatus shall be cleaned by pouring out the remaining material into a waste receptacle. Then, with the drum vertical, the side of the drum is tapped with a soft hammer to remove the loose material from the internal surfaces of the drum.

6.2.4 Test procedure

Remove the inlet and outlet stages at both ends of the drum. Spread the test sample evenly along the bottom of the drum. Reassemble both the inlet stage with a fresh protective filter, and the outlet stage with fresh foams and filters.

The timing circuit is then switched on and the test programme allowed to proceed. At the end of the test, carefully remove the foams and the filter from the outlet end of the drum and place them in an environmentally controlled balance room, taking care not to disturb the collected sample.

For each material carry out at least three runs (all with a cleaned drum and fresh sets of foams and filter), and increase the number of runs if the relative standard deviation of the measured dustiness mass fractions are high.

6.2.5 Weighing the foams and filters

The mass of the collected sample is determined by weighing the foams and filters before and after the test. All weighing shall be done in accordance with ISO 15767. After the test, the foams and filter are reweighed in the same sequence. As the test materials and filters are sensitive to moisture and electrostatic conditions in the atmosphere, it is essential that a protocol be followed as to when the mass indicated by the balance should be recorded. The reading of the balance should be taken at a set period (e.g. 30 s) after the specimen is placed on the balance pan and the balance door closed, or when the reading of the balance is stabilised.

In order to minimise the risk of disturbance and loss of material foams and filters should be handled or lifted only at their edges and kept to a minimum. Gloves should be worn or tweezers used to lift or handle the foams, and only tweezers used when handling the filters.

The masses m of dust collected in the size selecting stages n are calculated by equation (1):

$$\Delta m_n = (m_{\mathrm{f,S}n} - m_{\mathrm{i,S}n}) - (m_{\mathrm{f,C}n} - m_{\mathrm{i,C}n}) \quad (1)$$

where

Δm_n is the mass of dust collected by the n th stage, in milligrams;

$m_{\mathrm{f,S}n}$ is the final mass of the n th test stage substrate, in milligrams;

$m_{\mathrm{i,S}n}$ is the initial mass of the n th test stage substrate, in milligrams;

$m_{\mathrm{f,C}n}$ is the final mass of the n th control stage substrate, in milligrams;

$m_{\mathrm{i,C}n}$ is the initial mass of the n th control stage substrate, in milligrams.

The n th test stage substrate corresponds to either the 800 pores per meter (20 ppi) foam, the 3 200 pores per meter (80 ppi) foam or the backing filter in the foam/filter assembly. The use of the control stage substrates enables the correction of any mass change in the foams and filters due to changing environmental conditions between the two weighings.

6.2.6 Determination of the inhalable, thoracic and respirable dustiness mass fractions

The dustiness mass fraction of each health-related fraction, given in milligrams per kilogram (mg kg^{-1}), is calculated by dividing the mass collected from each health-related fraction, in milligrams, by the mass, in kilograms, of the material placed in the test apparatus.

The dustiness mass fractions shall be calculated using equations (2) to (4):