BS EN 15051-2:2013

BSI Standards Publication

Workplace exposure — Measurement of the dustiness of bulk materials

Part 2: Rotating drum method

bsi.

...making excellence a habit.™

National foreword

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 Together with BS EN 15051-1:2013 and BS EN 15051-3:2013 it supersedes BS EN 15051:2006, which is withdrawn.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

ISBN 978 0 580 76565 0

ICS 13.040.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 December 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 15051-2

November 2013

ICS 13.040.30

Supersedes EN 15051:2006

English Version

Workplace exposure - Measurement of the dustiness of bulk materials - Part 2: Rotating drum method

Exposition sur les lieux de travail - Mesurage du pouvoir de resuspension des matériaux pulvérulents en vrac - Partie 2: Méthode du tambour rotatif

Exposition am Arbeitsplatz - Messung des Staubungsverhaltens von Schüttgütern - Teil 2: Verfahren mit rotierender Trommel

This European Standard was approved by CEN on 28 September 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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 United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 15051-2:2013: E

Contents

Page

Foreword

This document (EN 15051-2:2013) 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 15051-3:2013, 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 as reference test methods;

c) the test of equivalence between an alternative (candidate) test method and any of the test methods now given in this European Standard and in EN 15051-3:2013 has 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 rotating drum 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 values of more than 220 different bulk materials.

1 Scope

This European Standard specifies the rotating drum 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, thoracic and respirable fractions of this dust, with reference to existing European Standards, where relevant (see Clause 6).

This method is suitable for general bulk material handling processes, including all those processes where the bulk material is dropped, or can be dropped. It differs from the continuous drop method presented in EN 15051-3 in this European Standard, the same bulk material is repeatedly dropped, while in EN 15051-3, the bulk material is dropped only once, but continuously.

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. A standard sample volume is used.

This European Standard is not applicable to test the dust released when solid bulk materials are mechanically reduced (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*

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)*

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.

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

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 rotating drum test method described in Clause 5.

4.7 Replicate tests

Replicate tests shall be carried out according to 5.7.

4.8 Reporting

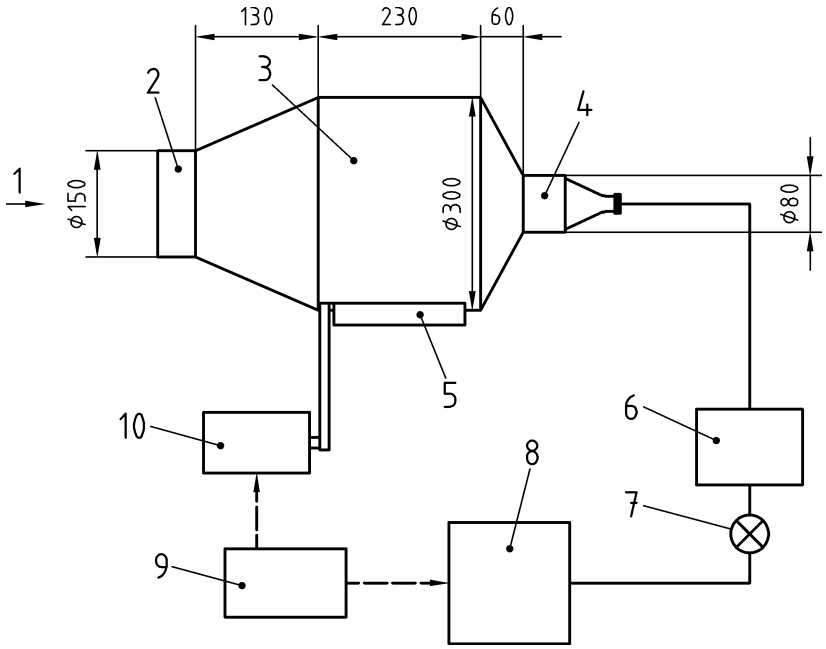
The test results shall be reported as specified in Clause 7.

5 Rotating drum 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 air flow
2 inlet stage (protective filter)
3 dust generation section - rotating drum
4 outlet stage/dust sampling system (two particle size-selective foam stages and a back-up filter)
5 rollers
6 in-line mass flow meter
7 control valve
8 vacuum pump
9 timer (timing control circuit)
10 drive motor

General tolerances according to EN 22768-1

Figure 1 — Outline of the rotating drum test apparatus

The test apparatus comprises a 300 mm diameter stainless steel drum rotating at 4 min^{-1}, equipped with eight longitudinal vanes to lift and let fall a known volume of the bulk material under test (the dust generation section (3)), and a three-stage dust sampling system (the outlet stage (4)) through which the emitted dust cloud is drawn by a vacuum pump (8) at a flow rate of 38 l min^{-1} for the duration of the test. The stainless steel vanes of 230 mm length and 25 mm height are fixed longitudinally to the internal walls of the drum and point radially inwards towards the centre of the drum. The test apparatus shall be earthed.

The dust sampling system (4) comprises two particle size-selective foam stages in series followed by a back-up filter. Polytetrafluorethylene (PTFE) spacer rings of size 80 mm diameter and 2 mm thickness are used to separate the two foam stages and the back-up filter to prevent cross contamination. Dust entering the conical passage and into the sampling system gives an estimate of the inhalable fraction. The size selectors, in the form of cylindrical plugs of 800 pores per metre (20 pores per inch) and 3 200 pores per metre (80 pores per inch) porous metal foam, are chosen to select the thoracic and the respirable fractions, respectively. The

foams and the back-up filter are weighed before and after the test to provide the dustiness estimates of the three size fractions.

A glass fibre protective filter with a diameter of 150 mm is on the inlet of the drum (2) to prevent dust contamination and to spread the air flow into the drum.

The air flow rate through the test apparatus is monitored using an in-line mass flowmeter (6), and this also provides measurement of the volume of air sampled. A timing control circuit (9) automatically controls the operation of the test apparatus.

5.2 Particle size-selective foams

Porous metal foam size selectors with a reticulated open-cell structure are used to select the thoracic and respirable dust fractions [1)]. Both size selectors have a diameter of 80 mm, the 800 pores per metre (20 pores per inch) foam has two layers of 10 mm thickness, and the 3 200 pores per metre (80 pores per inch) foam is a single layer of 12 mm thickness.

5.3 Filters

Filters with a diameter of 80 mm are used to collect the respirable particles that penetrate the foams. The filter shall have a collection efficiency of at least 99 %. Choice of filter material depends on subsequent analysis.

5.4 Ancillary equipment

The balance room or chamber, where weighing is carried out, shall have a temperature and humidity maintained at a stable level, so that an acceptable weighing uncertainty is obtained, see ISO 15767.

An analytical balance capable of weighing 250 g to a resolution of 0,1 g shall be available for weighing the samples of bulk material.

An analytical balance capable of weighing 150 g to a resolution of 0,01 mg shall be used for accurate determination of the foams and filters. The weighing chamber of the analytical balance shall be large enough to hold an 80 mm filter without it touching the walls. A weighing frame to position the foams and filters on the balance pan may be used.

5.5 Preparation of test sample

Test samples shall be extracted from the bulk material using a method which will result in representative sampling (see EN 15051-1:2013, 5.3). A minimum of six samples is prepared. Sample bottles able to be sealed shall be used to minimise contamination of the atmosphere.

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

5.6 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 test 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.

1) Such foams are manufactured by Dunlop Ltd, and are available from the supplier of the test apparatus, JS Holdings. Stevenage, UK. This information is given for the convenience of users of this European Standard and does not constitute an endorsement by CEN of the products named. Equivalent products may be used if they can be shown to lead to the same results.

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, clean the apparatus by pouring out the remaining bulk 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 bulk material from the internal surfaces of the drum.

5.7 Running the test apparatus

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 filter and foams. Unused stage substrates from the same batches used for the test are taken as control for weighing.

The timing circuit is then switched on and the test programme is allowed to proceed for 1 min. 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. Reweigh test and control foams and filters according to 5.8.

For each bulk 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 deviations of the average measured dustiness mass fractions is > 10 %.

5.8 Weighing the foams and filters

The mass of the collected sample is determined as the difference between the weights of the foams and filters before and after the test corrected by the corresponding control stages results. 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 shall be recorded. The reading of the balance shall 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 bulk material, foams and filters shall be handled or lifted only at their edges, and handling shall be kept to a minimum. Gloves shall be worn or tweezers used to lift or handle the foams, and only tweezers used when handling the filters. In order to prevent contamination of the balance pan during weighing of the dust-laden foams, the use of weight-constant trays to contain the foams during weighing may be considered.

The masses *m* of dust collected in the size selecting stages *n* are calculated for each single test by Formula (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 (mg);

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

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

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

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

The *n*th test stage substrate corresponds to either the 800 pores per metre (20 pores per inch) foam, the 3 200 pores per metre (80 pores per inch) foam or the back-up 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 weightings.

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

The dustiness mass fraction of each health-related fraction, given in milligrams per kilogram, is calculated by dividing the mass collected from each health-related fraction, in milligrams, by the mass, in kilograms, of the bulk material placed in the test apparatus.

The dustiness mass fractions shall be calculated for each single test using Formulae (2) to (4):

$$w_{\mathrm{I,A}} = \frac{\Delta m_{20} + \Delta m_{80} + \Delta m_{\mathrm{f}}}{m_{\mathrm{s}}} \tag{2}$$

$$w_{\mathrm{T,A}} = \frac{\Delta m_{80} + \Delta m_{\mathrm{f}}}{m_{\mathrm{s}}} \tag{3}$$

$$w_{\mathrm{R,A}} = \frac{\Delta m_{\mathrm{f}}}{m_{\mathrm{s}}} \tag{4}$$

where

$w_{\mathrm{I,A}}$ is the inhalable dustiness mass fraction, in milligrams per kilogram (mg/kg);

$w_{\mathrm{T,A}}$ is the thoracic dustiness mass fraction, in milligrams per kilogram (mg/kg);

$w_{\mathrm{R,A}}$ is the respirable dustiness mass fraction, in milligrams per kilogram (mg/kg);

m_{s} is the mass of the test sample, in milligrams (mg);

Δm_{20} is the mass collected by the 800 pores per metre (20 pores per inch) foam, in milligrams (mg);

Δm_{80} is the mass collected by the 3 200 pores per metre (80 pores per inch) foam, in milligrams (mg);

Δm_{f} is the mass collected by the back-up filter, in milligrams (mg).

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.

6 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 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 rotating drum method is given in Table 1. The scheme is based on the results of more than 220 different bulk materials that have been investigated up to August 2010. The classification limits correspond to the quartiles of those results.

NOTE Alternative classification schemes are possible, see Introduction.

Table 1 — Dustiness classification for rotating drum method

Category of dustiness	Inhalable dustiness mass fraction, $w_{I,A}$ mg/kg	Thoracic dustiness mass fraction, $w_{T,A}$ mg/kg	Respirable dustiness mass fraction, $w_{R,A}$ mg/kg
Very low	< 300	< 80	< 10
Low	300 to 650	80 to 300	10 to 60
Moderate	> 650 to 3 000	> 300 to 1 000	> 60 to 210
High	> 3 000	> 1 000	> 210

7 Test report

The test report shall contain at least the following information:

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 test method 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 given as mass ratio in per cent (%), with specification of analytical method;

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

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

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 ($w_{I,A}$, $w_{T,A}$, $w_{R,A}$,), depending on the test method used, in milligrams per kilogram (mg/ kg) for each replicate test, plus the mean and the relative standard deviation of all test results;

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

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

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™