Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

Installations and equipment for liquefied natural gas — Testing of insulating linings for liquefied natural gas impounding areas

The European Standard EN 12066 : 1997 has the status of a British Standard

ICS 75.200

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

National foreword

This British Standard is the English language version of EN 12066 : 1997.

The UK participation in its preparation was entrusted to Technical Committee GSE/38, Installation and equipment for LNG, which has the responsibility to:

– aid enquirers to understand the text;

– present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

– monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled 'International Standards Correspondence Index', or by using the 'Find' facility of the BSI Standards Electronic Catalogue.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 8, an inside back cover and a back cover.

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on 15 February 1998

© BSI 1998

Amendments issued since publication

Amd. No.	Date	Text affected

ISBN 0 580 28980 X

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12066

September 1997

ICS 75.200

Descriptors: Gas installation, liquefied natural gas, vats, protective coatings, insulation, evaporation, water bath evaporation, operating requirements, tests, test equipment, measurements, coefficients, computation

English version

Installations and equipment for liquefied natural gas — Testing of insulating linings for liquefied natural gas impounding areas

Installations et équipements relatifs au gaz naturel liquéfié — Essais de revêtements isolants des cuvettes de rétention de gaz naturel liquéfié

Anlagen und Ausrüstung für Flüssigerdgas — Prüfung von Wärmedammbeschichtungen für Flüssigerdgas-Auffanbecken

This European Standard was approved by CEN on 22 August 1997.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

© 1997 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. EN 12066 : 1997 E

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 282, Installation and equipment for LNG, the secretariat of which is held by AFNOR.

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 March 1998, and conflicting national standards shall be withdrawn at the latest by March 1998.

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

Contents

© BSI 1998

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

1 Scope

This European Standard specifies the tests to be carried out in order to assess the suitability of insulating linings used in LNG impounding areas.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1160	*Installations and equipment for liquefied natural gas — General characteristics of liquefied natural gas*
prEN 12379	*Testing concrete — Making and curing specimens for strength tests*

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1 liquefied natural gas (LNG)

See EN 1160.

3.2 insulating lining

Material or layers of materials designed to minimize evaporation of an LNG pool.

3.3 water absorption ratio

Ratio between the volume of water absorbed and the calculated volume of the insulating lining specimen subjected to testing.

4 Description of the means of and the equipment required for testing

4.1 Characteristics of test pieces

The dimensions of the test pieces shall be defined in accordance with the dimensions of the test rig defined in **4.2.1**.

The thickness of the test piece shall be the same as that of the insulating lining of the LNG impounding area.

The manufacturing and installation technology of the test piece shall be the same as that of the impounding area insulating lining.

The test piece shall be stored in accordance with the manufacturer's recommendations. Specifically, if the material applied is concrete, the test pieces shall be built, cured and stored in compliance with prEN 12379.

4.2 Equipment used to measure the evaporation coefficient of LNG in contact with the insulating lining

4.2.1 *Test rig*

A test piece shall be hermetically sealed onto the base of a right-angled parallelepiped shaped tank whose sides and bottom are built of a rigid insulating material having a thermal conductivity less than 0,050 W/(m·K).

The quantity of LNG necessary for the test shall be discharged over the test piece in less than 0,5 s.

The discharged volume is equal to the product of the test piece surface and the desired height of LNG within a limit deviation of ± 5 %.

After the LNG discharge, the initial height of LNG over the test piece shall be about 2,5 cm.

Annex A specifies the characteristics of the test rig.

NOTE. Given the different thermal behaviour of other cryogenic lquids, none of them can replace LNG to measure the evaporation coefficient.

4.2.2 Measuring equipment

The evaporation coefficient of LNG in contact with the insulating lining shall be determined on the basis of continuous weighings of the tank placed on a scale, following LNG discharge over the test piece.

For that purpose, an electronic scale shall be used in combination with a high-speed recorder.

Annex B specifies the characteristics of the measuring equipment.

4.3 Equipment used to measure the water absorption ratio of an insulating lining

4.3.1 Water tank

The water tank shall be designed in such a way that the test piece is fully immersed and its six faces remain in permanent contact with water during immersion.

4.3.2 Measuring equipment

The water absorption ratio of the test pieces shall be measured after successive weighings of test pieces on previously calibrated scales. The weighing scale shall be able to measure with an accuracy better than 1 %.

5 Test method

5.1 Measurement of the evaporation coefficient of LNG in contact with the insulating lining

5.1.1 *Procedure*

The test for the measurement of the evaporation coefficient of LNG in contact with the insulating lining shall be performed at an initial test rig temperature of (20 ± 5) °C and at atmospheric pressure in accordance with the following procedure:

a) install the test piece at the base of the tank;

b) install the tank on the scale;

c) install the LNG discharge system above the tank;

© BSI 1998

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

d) fill the tip-over system;

e) discharge the LNG over the test piece within a period of less than 0,5 s;

f) record the tank weight at high frequency for a period of at least 2 min;

g) visually inspect the test rig to verify its tightness.

5.1.2 ***The parameter derived from the measurements***

The evaporation coefficient of LNG, K_p, in contact with the insulating lining shall be calculated in accordance with annex C, by quantifying the rate of evaporation of LNG in contact with the insulating lining under test.

5.2 Measurement of the water absorption ratio of the insulating lining

5.2.1 ***Procedure***

The test for the measurement of the water absorption ratio of the insulating lining shall be performed at a temperature of (20 ± 5) °C in accordance with the following procedure:

a) weigh a test piece before testing;

b) immerse in water for 1 h;

c) weigh after draining for 1 h;

d) immerse in water for one day;

e) weigh after draining for 1 h;

f) immerse in water for two days;

g) weigh after draining for 1 h;

h) repeat the last two sequences (f and g) six times.

5.2.2 ***Parameters derived from the measurements***

The water absorption ratio of the insulating lining shall be quantified by calculating the following parameters:

a) the water absorption ratio of each test piece after each weighing;

b) the maximum value of water absorption ratio of the insulating lining.

Annex D specifies the method of calculation of the above parameters.

6 Testing

The tests shall be carried out on the three test pieces in order to determine the evaporation coefficient of LNG in contact with the insulating lining under the following conditions:

a) the insulating lining is dry as delivered by the manufacturer;

b) the insulating lining is saturated with water following immersion for 15 days;

c) due to the fact that the insulating material can change its characteristics under the influence of atmospheric agents such as rain, frost, ultra-violet rays etc, it is recommended to determine the evaporation coefficient of LNG after having subjected the insulating lining to an ageing procedure. In this case, the ageing procedure shall be defined by the user and agreed by the insulating manufacturer. The simulated lifetime shall be defined by the user.

7 Test report

The results of the tests shall be recorded in a report containing the following information:

a) the history of the test pieces before testing, such as storage and transportation conditions (temperature, humidity, etc), time between manufacturing and testing and conditions of sampling;

b) the evaporation coefficient of LNG in contact with the insulating lining in the dry condition (see clause **6**a));

c) the maximum value of the water absorption ratio of the insulating lining (see **5.2.2**b));

d) the evaporation coefficient of LNG in contact with the insulating lining saturated with water following immersion for 15 days (see clause **6**b));

e) the evaporation coefficient of LNG in contact with the insulating lining following the accelerated ageing procedure, if requested (see clause **6**c)).

© BSI 1998

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

Annex A (normative)
Specification of the test rig

A.1 Description of the test rig

The test rig shall consist of the following (see figure A.1):

– a tank containing the test piece;

– a system of LNG discharge.

The materials which are likely to come in contact with LNG shall comply with the requirements of EN 1160.

A.2 Specification of the tank

The tank shall be designed so that its base is a square whose side is between 400 mm and 600 mm.

It shall consist of plates of a rigid insulating material forming the sides and base.

The test piece shall be sealed onto the base.

In order to avoid LNG penetration along the edges of the test piece and under the test piece, special care shall be taken when making the joints between the different tank components.

A.3 Specification of the LNG discharge system

The LNG discharge system shall consist of:

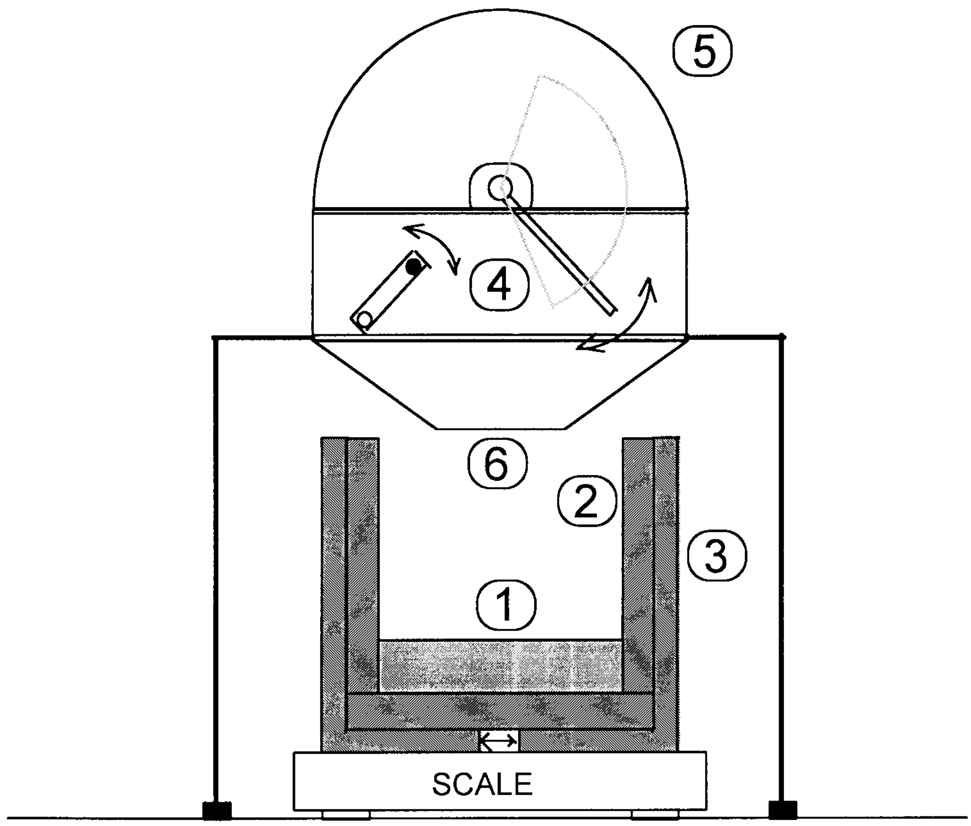
– a quick tip-over system;

– a cover to prevent any LNG splashing;

– a hopper to guide the LNG discharge into the tank.

A.4 Regulations

Attention is drawn to existing European Standards in the field of safety, for example prEN 50145, for the design and operation of the test rig.



1 Test piece
2 Rigid insulation material
3 Tightening device
4 Quick tip-over system
5 Cover
6 Hopper

Figure A.1 Example of test rig

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

Annex B (normative)

Measuring equipment used to determine the evaporation coefficient of LNG in contact with the insulating lining

B.1 Specification of the scale

The scale used to determine the evaporation coefficient of LNG in contact with the insulating lining shall have the following specification:

a) sensitivity: 5×10^{-3} kg;

b) indicator precision: 5×10^{-3} kg;

c) frequency of measurement: at least 20 Hz.

B.2 Specification of related recorder

The recorder connected to the scale may be of the magnetic or digital tape recording type. Regardless of the type, its data acquisition frequency shall be at least 20 Hz.

Annex C (normative)

Method of calculation of the evaporation coefficient of LNG in contact with the insulating lining

C.1 Calculation of LNG mass remaining in the tank as a function of time

The rate of evaporation $V_r(t)$ expressed in metres per second, as a function of the time (t) that the LNG is in contact with the insulating lining is calculated with a law of the following type:

$$V_r(t) = \frac{K_r}{\sqrt{t}} \quad \text{(C.1)}$$

where:

K_r is the evaporation coefficient of LNG in contact with the insulating lining expressed in m/s½.

Consequently, the variation in the mass of evaporated LNG, $\frac{dM_e(t)}{dt}$, is expressed as a function of time by a law of the following type:

$$\frac{dM_e(t)}{dt} = \frac{A}{\sqrt{t}} \quad \text{(C.2)}$$

where:

$M_e(t)$ is the mass of evaporated LNG expressed in kg;

A is a dimensional constant determined experimentally expressed in kg/s½.

Consequently, the LNG mass $M(t)$ remaining in the tank is expressed as a function of time by the following law:

$$M(t) = M_0 - M_e(t) \quad \text{(C.3)}$$

$$M(t) = M_0 - 2A\sqrt{t} \quad \text{(C.4)}$$

where:

M_0 and A are experimental coefficients determined after applying the method of least squares to the mass measurements of LNG remaining in the tank as a function of time.

C.2 Calculation of evaporation coefficient of LNG in contact with insulating lining

The coefficient A_i determined for a test piece referenced i, has the following expression:

$$A_i = K_{g_i} \cdot \rho_{LNG_i} \cdot (S_{ep} + S_{w_i}) \quad \text{(C.5)}$$

where:

K_{g_i} (expressed in m/s½) is the overall evaporation coefficient of LNG in contact with materials wetted during the discharge (sides and test piece referenced i);

ρ_{LNG_i} is the LNG density expressed in kg/m³;

S_{ep} is the surface area of an LNG-wetted test piece expressed in m²;

S_{w_i} is the surface area of the side walls initially wetted by the LNG expressed in m².

The surface area S_{w_i} is calculated as follows:

$$S_{w_i} = \frac{M_{0_i} \cdot p}{\rho_{LNG_i} \cdot S_{ep}} \quad \text{(C.6)}$$

where:

M_{0_i} is the initial mass of LNG discharged over the test piece referenced i expressed in kg;

p is the perimeter of the test piece expressed in metres.

Coefficient K_{g_i} has the following expression:

$$K_{g_i} = \frac{S_{ep}}{S_{ep} + S_{w_i}} \cdot K_{ep_i} + \frac{S_{w_i}}{S_{ep} + S_{w_i}} \cdot K_w \quad \text{(C.7)}$$

where:

K_{ep_i} is the evaporation coefficient of LNG in contact with the insulating lining of the test piece referenced i expressed in m/s½;

K_w is the evaporation coefficient of LNG in contact with the tank walls, determined in **C.3** expressed in m/s½.

The evaporation coefficient of LNG in contact with the insulating lining of the test piece referenced i, is expressed as follows:

$$K_{ep_i} = \frac{A_i}{\rho_{LNG_i} \cdot S_{ep}} - \frac{S_{w_i}}{S_{ep}} \cdot K_w \quad \text{(C.8)}$$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

The evaporation coefficient of LNG in contact with the insulating lining K_r is the mean value of the coefficients calculated for each of the three test pieces:

$$K_r = \frac{1}{3}\sum_{i=1}^{3} K_{ep_i} \qquad \text{(C.9)}$$

C.3 Calculation of evaporation coefficient of LNG in contact with tank walls

The evaporation coefficient of LNG in contact with the test piece referenced i of the same material as the tank walls is expressed as follows:

$$K_{w_i} = \frac{A_i}{\rho_{LNG_i} \cdot \left(S_{ep} + S_{w_i}\right)} \qquad \text{(C.10)}$$

The evaporation coefficient of LNG in contact with the material of the tank walls K_W is the mean value of the coefficients calculated as follows:

$$K_w = \frac{1}{3}\sum_{i=1}^{3} K_{w_i} \qquad \text{(C.11)}$$

C.4 Example of calculation

The tests described below were performed with three square test pieces having the following dimensions:

– side: 400 mm;

– thickness: 70 mm;

– surface area: 0,16 m^2.

The weight of the LNG discharged over the test piece was measured by means of an electronic scale taking readings every 50 ms for 2 min.

The tank walls were made of polyurethane. Hence, the K_w coefficient has a value equal to $0,83 \times 10^{-4}$ m/s½.

Table C.1 indicates, for each test piece referenced i, the values of the following coefficients and physical parameters:

– the dimensional constant A_i, determined according to a law of the following type, after applying the method of least squares to the measurements of the LNG mass remaining over the test piece in the tank as a function of time:

$$M(t) = M_0 - 2A_i\sqrt{t} \qquad \text{(C.12)}$$

– the LNG density, ρ_{LNG_i};

– the surface area S_{w_i} of the tank walls initially wetted by the LNG;

– the evaporation coefficient of LNG in contact with the insulating lining, K_{ep_i}.

The evaporation coefficient of LNG in contact with the insulating lining K_r is:

$$K_r = \frac{17{,}33 + 17{,}93 + 19{,}19}{3} \times 10^{-5} \text{ m/s}^{1/2}$$

$$K_r = 18{,}15 \times 10^{-5} \text{ m/s}^{1/2}$$

C.5 Bibliography

Emission and dispersion. Chapter 15 *In:* Frank P. Lees, ed., *Loss prevention in the process industries.*

Liquids spills on the ground — Spreading and evaporation. Chapter 6 *In:* Torstein K. Fannelöp, ed., *Fluid mechanics for industrial safety and environmental protection.*

MCNAUGHTON, D.J., and C.M. BERKOWITZ. Heavy gas and risk assessment. *In:* Hartwig, ed., *Overview of U.S. research activities in the dispersion of dense gases.*

SHAW P., and F. BRISCOE. *Evaporation from spills of hazardous liquids on land and water.* SRD, ed.

Annex D (normative)

Method of calculation of the water absorption ratio of insulating lining

D.1 Water absorption ratio of a test piece after immersion

The water absorption ratio, P_{r_t}, after an immersion time, t, of a test piece is given by the following formula:

$$P_{r_t} = \frac{m_t - m_0}{m_0} \qquad \text{(D.1)}$$

where:

m_t is the mass of the test piece after immersion time t and after 1 h of dripping, on a flat surface;

m_0 is the mass of the test piece before the first immersion.

Table C.1 Values of coefficients and physical parameters required for the calculation of the evaporation coefficient of LNG

Reference of the test piece	1	2	3
A_i in kg/s½	0,0131	0,0136	0,0145
ρ_{LNG_i} in kg/m³	453,7	453,7	453,7
S_{w_i} in m²	0,0137	0,0153	0,0149
K_{ep_i} in m/s½	$17{,}33 \times 10^{-5}$	$17{,}93 \times 10^{-5}$	$19{,}19 \times 10^{-5}$

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

D.2 Maximum value of the water absorption ratio of the insulating lining

The value of water absorption ratio of each test piece determined experimentally as a function of immersion time shall be adjusted by the least squares method by using a law of the following type:

$$P_{r_i}(t) = \frac{a_i t^2 + b_i t}{t^2 + c_i t + d_i} \qquad (D.2)$$

where:

$P_{r_i}(t)$ is the water absorption ratio function of the test piece referenced i;

a_i, b_i, c_i, d_i are the adjustment coefficients of the function $P_{r_i}(t)$.

The maximum value of the water absorption ratio for the test piece referenced i is:

$$P_{r_{max_i}} = \lim_{t \to \infty} \left(\frac{a_i t^2 + b_i t}{t^2 + c_i t + d_i} \right) \qquad (D.3)$$

$$P_{r_{max_i}} = a_i \qquad (D.4)$$

The maximum value of the water absorption ratio for the insulating lining is the following:

$$P_{r_{max}} = \frac{1}{3} \sum_{i=1}^{3} P_{r_{max_i}} \qquad (D.5)$$

D.3 Numerical example

The table D.1 defines for each test piece:

– the weight, m_0, before the first immersion;

– the weights m_t after each immersion and the corresponding values of the water absorption ratio P_{r_t};

– the values of the adjustment coefficients a_i, b_i, c_i, d_i;

– the maximum values of the water absorption ratio $P_{r_{max_i}}$.

The maximum value of the water absorption ratio is:

$$P_{r_{max}} = \frac{10,61 + 10,28 + 9,55}{3} \ \%$$

$$P_{r_{max}} = 10,15\ \%$$

Table D.1 Values of the numeric example

Reference of the test piece	**1**		**2**		**3**	
m_0 **in** kg	**36**		**36**		**36**	
Immersion duration	m_t kg	P_{r_t} %	m_t kg	P_{r_t} %	m_t kg	P_{r_t} %
1 h	37,53	4,25	37,33	3,68	37,17	3,25
1 day	38,02	5,62	37,99	5,52	37,72	4,77
3 days	38,67	7,42	38,61	7,24	38,30	6,39
5 days	38,97	8,26	38,90	8,05	38,59	7,19
7 days	39,15	8,75	39,07	8,52	38,76	7,67
9 days	39,27	9,08	39,18	8,82	38,87	7,98
11 days	39,35	9,30	39,25	9,04	38,95	8,21
13 days	39,41	9,47	39,31	9,20	39,02	8,38
15 days	39,46	9,60	39,36	9,32	39,06	8,51
a_i	10,61		10,28		9,55	
b_i	221,01		220,58		218,89	
c_i	60,90		60,62		69,87	
d_i	−7,36		1,09		−0,62	
$P_{r_{max_i}}$	10,61		10,28		9,55	

© BSI 1998

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

blank

Licensed copy: Lee Shau Kee Library, HKUST, Version correct as of 03/01/2015, (c) The British Standards Institution 2013

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

If permission is granted, the terms may include royalty payments or a licensing agreement. Details and advice can be obtained from the Copyright Manager. Tel: 020 8996 7070.

BSI
389 Chiswick High Road
London
W4 4AL