BRITISH STANDARD

BS EN 14150:2006

Geosynthetic barriers — Determination of permeability to liquids

The European Standard EN 14150:2006 has the status of a British Standard

ICS 59.080.70

British Standards

National foreword

This British Standard is the official English language version of EN 14150:2006.

The UK participation in its preparation was entrusted to Technical Committee B/553, Geosynthetics, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep 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 Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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

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 13 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2006

ISBN 0 580 49071 8

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 14150

June 2006

ICS 59.080.70

English Version

Geosynthetic barriers - Determination of permeability to liquids

Géomembranes - Détermination de la perméabilité aux liquides

Geosynthetische Dichtungsbahnen - Bestimmung der Flüssigkeitsdurchlässigkeit

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 14150:2006: E

Contents

Page

Foreword

This European Standard (EN 14150:2006) has been prepared by Technical Committee CEN/TC 189 "Geosynthetics", the secretariat of which is held by IBN/BIN.

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 December 2006, and conflicting national standards shall be withdrawn at the latest by December 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.

1 Scope

This European Standard specifies a method for measuring the steady-state liquid flow through a geosynthetic barrier, used to contain liquids in long-term applications.

The test method and described apparatus allow the measurement of flows accurately down to 10^{-6} m^3/m^2/day. In particular circumstances where testing indicates that values obtained for a geosynthetic barrier lie below the threshold of sensitivity of this test method, then the value of liquid flow is declared as being less than 10^{-6} m^3/m^2/day.

Due to its long duration this test method is not suitable for production control testing.

Geosynthetic clay liners cannot be tested with this apparatus.

2 Normative references

Not applicable

3 Principle

A differential hydraulic pressure is applied between the two sides of a geosynthetic barrier. It is kept constant during the test at 100 kPa, the upstream pressure being set to 150 kPa, and the downstream pressure to 50 kPa.

The flow through the geosynthetic barrier is calculated from the variations of the liquid volume measured on both sides of the geosynthetic barrier.

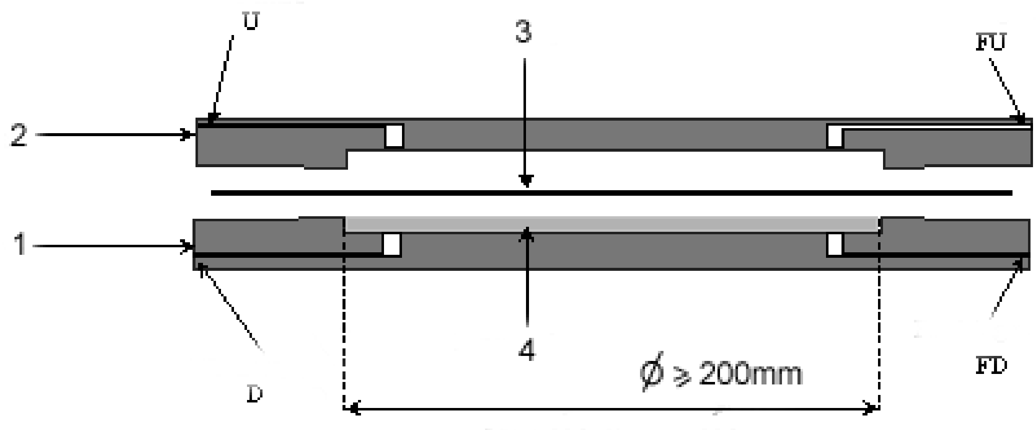
NOTE 1 This test is conducted with water, but can also be performed with other liquids, providing chemical resistance and compatibility of the apparatus is ensured.

NOTE 2 In the light of laboratory experience, test procedural improvement and equipment enhancement the sensitivity threshold of the test procedure should be reviewed and the applicability of the test procedure to the product permeability assessed at regular intervals, not exceeding 12 months.

4 Apparatus

4.1 Cell

The two-part cell (see Figure 1) is made of stainless steel. The cell shall resist to oxidation during long-term immersion. In each part of the cell, a cavity allows to apply a hydraulic pressure. A porous disc placed in the downstream cavity prevents deformations of the geosynthetic barrier.



Key

1	downstream part	U	water inlet
2	upstream part	D	water outlet
3	geosynthetic barrier	FU	flushing valve upstream
4	porous plate	FD	flushing valve downstream

Figure 1 — Schematic representation of a test cell

The cell shall be designed to clamp the specimen without any leaks. There is no tightening system necessary, as clamping between flat surfaces is usually sufficient. For some materials, a sealant may be necessary. Any sealant non-sensitive to water and avoiding leaks can be used. In the case of bituminous geosynthetic barriers, a bitumen rubber sealant can be used.

The measuring chambers shall have a nominal diameter equal to or greater than 200 mm. This diameter shall be measured with an accuracy equal to or better than 1 mm.

The cell is equipped with a liquid inlet on the upstream part (U-valve) and a liquid outlet on the downstream part (D-valve) and flushing valves on each part (FU- and FD-valves).

The cell should be oriented vertically to allow an easier and better air flushing. The flushing valves (FU and FD) should be placed on top of the cell and the inlet (U) and outlet (D) should be on the bottom of the cell.

NOTE The cell can also include, on both parts, a ring-shaped control chamber. The downstream control chamber will be equipped with a porous ring-shaped plate. Each ring-shaped chamber will be connected to an independent volume measuring device and a pressure delivery system, in order to apply the same pressure as in the corresponding measuring chamber. These ring-shaped chambers are there to minimise deformation in the measuring chamber.

4.2 Volume measuring devices and pressure delivery system

These two devices are generally associated.

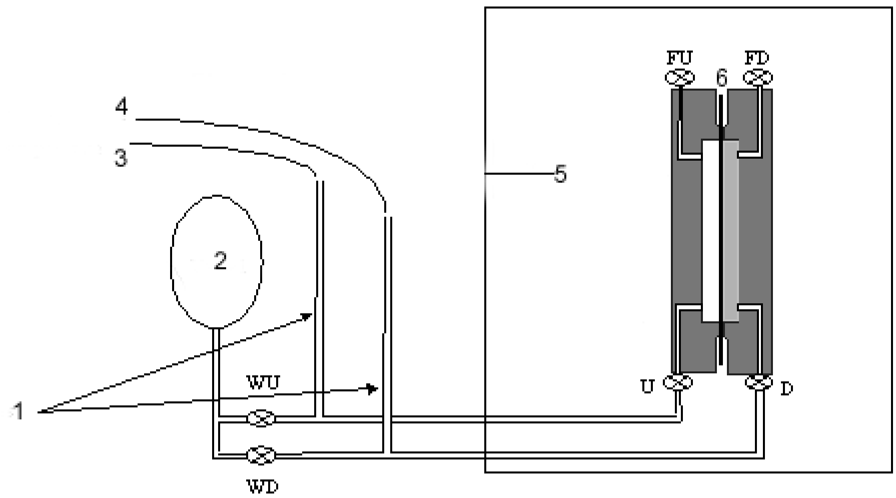
The volume measuring equipment shall be able to measure liquid flows through the geosynthetic barrier smaller than 10^{-6} m^3 /m^2/day.

The accuracy of the volume measurement shall be at least 10^{-8} m^3.

The accuracy of the pressure applied on each side of the geosynthetic barrier shall be ± 2 kPa.

The volume measurements can be achieved using capillary tubes (Type A device) or pressure-volume controllers (Type B device).

— Type A (see Figure 2): 30 cm long tubes can be used. To reduce the effects of evaporation the tube diameter should be less than 3 mm. The pressure is applied by means of air pressure in capillary tubes and controlled with a regulator. A liquid vessel connected to the cell, between each capillary tube and the cell, allows the cavities to be filled before the test and enables the adjustment of liquid levels in capillary tubes during the test. Due to temperature effects on volume, tests performed with this kind of apparatus should be carried out in a thermostatic chamber (23 ± 0,2) °C.

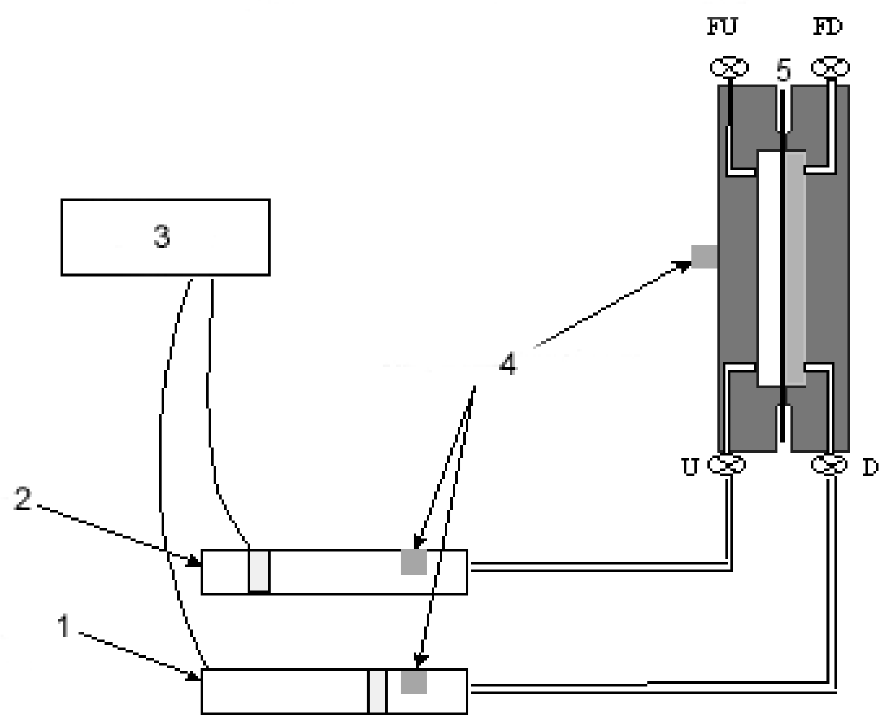


Key

1	capillary tubes	WU	water regulator valve upstream
2	vessel	WD	water regulator valve downstream
3	upstream pressure	FU	flushing valve upstream
4	downstream pressure	FD	flushing valve downstream
5	thermostatic chamber (to ± 0,1 °C)	U	water inlet
6	geosynthetic barrier	D	water outlet

Figure 2 — Schematic representation of a Type A volume measuring device

— Type B (see Figure 3): this device allows the application of a constant pressure when measuring the volume. It consists of a cylinder in which a piston slides. A numerically controlled motor enables the application of the required pressure by moving the piston. A pressure sensor included in the system measures the pressure. The piston displacement corresponds to a variation of the volume of liquid. The volume of the controllers should be greater than 10^{-4} m^3.



Key

1	downstream controller	U	water inlet
2	upstream controller	D	water outlet
3	computer	FU	flushing valve upstream
4	temperature transducers	FD	flushing valve downstream
5	geosynthetic barrier		

Figure 3 — Schematic representation of a Type B volume measuring device

4.3 Liquid supply

It is recommended to use de-aired water (less than 1 mg/l of dissolved oxygen). De-aired liquid is necessary to minimize variations of volume due to temperature variations.

NOTE If the test is conducted with other liquids, volatility and safety problems should be taken into account.

4.4 Temperature control

When the test is carried out using a type A device then this shall be performed under a temperature of (23 ± 0,2) °C (using a thermostatic chamber). When the test is carried out using a type B device then a temperature of (23 ± 1) °C (in a controlled temperature room) shall be used.

With a type B device, at least three temperature transducers, placed on each pressure-volume controller and on the cell, should be used. Temperature measurements will then be used to correct volume variations (see 8.2). The temperature is measured with a precision of 0,2 °C.

5 Specimens

The specimens shall be clean and free from any visible defects.

If the geosynthetic barrier has a textured surface, it will be necessary to smooth the surface in the clamping area to achieve a good seating. In addition the uniformity of texturing shall be such that no undue deformation of the barrier takes place during the test. If the clamping area cannot be correctly machined to achieve a good seal or if the texturing causes deformation during the test, then the specimen shall not be submitted to the test.

NOTE In order to reduce testing time, it is recommended to immerse the specimen in the liquid at test temperature for 24 h prior to the commencement of the test.

6 Procedure

NOTE It is of the utmost importance to maintain the upstream pressure higher than the downstream pressure during the whole duration of the test, and between each stage.

6.1 Installation

6.1.1 General

The cell shall be dry and clean from oils. The valves U, D, FU and FD shall be open.

Place the specimen in the centre of the downstream part of the cell placed horizontally.

Place the upstream part of the cell and close it. Clamp the geosynthetic barrier to ensure perfect contact.

Place the cell on the testing bench and apply one of the following procedures.

6.1.2 Type A volume measuring devices:

- connect the cell to the volume measuring device;
- open U and the vessel valve WU and slowly fill the upstream cavity with liquid coming directly from the vessel. Continue filling until air previously in the cell is flushed out;
- close FU and establish a high level of liquid in the capillary tube where the level of liquid will decrease;
- close WU and apply a 10 kPa pressure on the upstream cavity;
- open D and the liquid vessel valve WD and slowly fill the downstream cavity with liquid; continue filling until all air previously in the cell is flushed out;

NOTE A better result may be obtained by vacuuming air from the downstream cavity with valve D closed and refilling the upstream cavity afterwards if necessary.

- close WD and FD;
- during both preparation and test stages, regularly adjust the level of liquid in both tubes. It may be necessary to fill the upstream capillary tube and empty the downstream capillary tube where the level of liquid will increase. To correct the liquid level in a tube, apply an appropriate pressure (50 kPa or 150 kPa) in the liquid vessel, open the liquid valve (WU or WD) and adjust the liquid level in the tube (upstream or downstream). Then close the liquid vessel valve (WU or WD).

6.1.3 Type B volume measuring devices:

— fill in upstream and downstream controller with liquid;

— fill the upstream part of the cell with liquid, coming directly from the liquid vessel; continue liquid filling until air previously in the cell is flushed out;

— close valve U;

— connect the upstream part to the corresponding controller, open valve U, and begin to empty the controller for a few seconds;

— set the controller pressure to zero and close valve FU; set the controller pressure to 10 kPa;

— slowly fill the downstream part of the cell with liquid coming directly from the liquid vessel (not represented in Figure 3); continue liquid filling until all air in the cell is flushed out;

— close valve D;

— connect the downstream part to the corresponding controller, open valve D, and begin to empty the controller for a few seconds;

— set the controller pressure to zero and close valve FD;

— at the end of the installation, the upstream pressure-volume controller should be three quarter filled and the downstream pressure-volume controller should be one quarter filled.

6.2 Preparation stages

6.2.1 General

These preparation stages will show any leakage. If the test is performed with type B equipment in a temperature controlled room at (23 ± 1) °C, the preparation stages will also enable the calculation of the coefficient(s) of temperature-volume dependence (see 7.2).

For type A devices the liquid levels in the capillary tubes shall be adjusted before each stage, and valves WD and WU shall be kept closed during the whole preparation stage.

6.2.2 First preparation stage

Valves U and D are open.

Apply a 60 kPa pressure in the upstream cavity, followed by a 50 kPa pressure in the downstream cavity. Wait until the volume is stabilised. Close valve U.

Measure downstream volume and temperature(s) for at least 72 h.

6.2.3 Second preparation stage

Valves U and D are open.

Apply a 150 kPa pressure in the upstream cavity, followed by a 140 kPa pressure in the downstream cavity. Wait until volumes are stabilised. Close valve D.

Measure upstream volume and temperature(s) for at least 72 h.

6.3 Test stage

Open valve D.

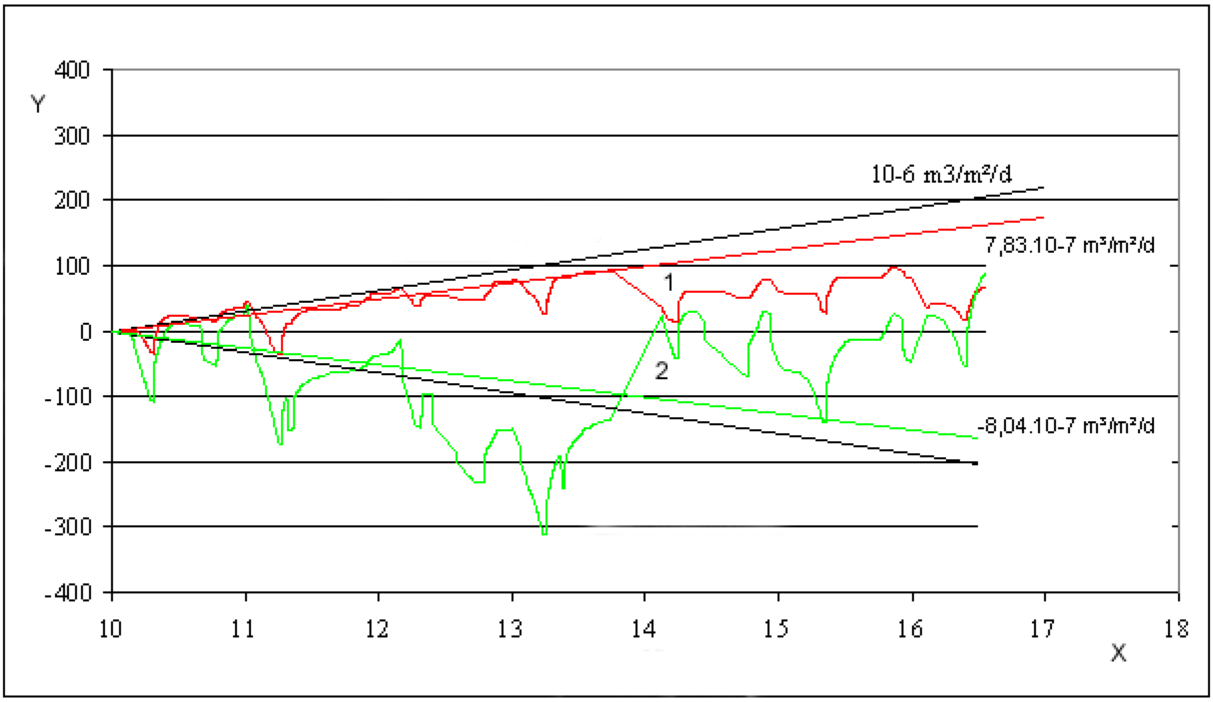
Apply a 150 kPa pressure in the upstream cavity, then a 50 kPa pressure in the downstream cavity.

Measure temperature(s) and volumes during the test.

For a type A device, regularly adjust liquid levels in capillary tubes as previously described.

The test duration shall be long enough to give an accurate mean value of the flow.

During the first days of the test, volume variations are not constant (see Figure 4). In practice this is mainly due to the deformation of the specimen under water pressure, and to the fact that the clamping may deform some geosynthetic barriers in the measuring chamber. This deformation is such that during the first two or three days of the measurement stage there are very important variations of volume due to the ‘flattening’ of the geosynthetic barrier caused by the hydraulic gradient and to the beginning of diffusion. The duration of this transition state depends on the type of geosynthetic barrier, and on the conditioning of the specimen.



Key

1 downstream volume x-axis: time (in days)

2 upstream volume y-axid: volume (in mm³)

Figure 4 — Graph of upstream and downstream volumes versus time (example)

After this period the regime is stabilised and volume variations are reasonably constant. The mean value of liquid flow is calculated from both upstream and downstream volume measurements made during the latter period. The time taken into account to calculate mean values of flow shall be at least 7 days.

NOTE 1 The data of the first days of test are generally not usable to calculate the liquid flow.

7 Calculation

7.1 Preparation stages

For the first preparation stage, plot the downstream volume versus time curve.

When the test is performed in a thermostatic room, calculate the mean value of the equivalent flow (m^3/m^2/day) by dividing the slope of the curve by the effective area of tested geosynthetic barrier. This flow, if measurable, is not a real flow through the geosynthetic barrier but corresponds to leaks.

When the test is performed in a temperature-controlled room, this data is used to calculate the coefficient(s) of volume-temperature dependence (see 8.2).

Repeat the same procedure with the upstream volume measured during the second preparation stage.

7.2 Volume-temperature dependence coefficients

Use a linear regression or a multi-linear regression method if more than one temperature transducer is used.

Provided leak flows are small, the variations of volume actually measured during preparation stage in the cavity concerned by the calibration stage are mainly due to temperature variations.

α_i, the coefficient of dependence of volume versus temperature "*i*" is determined according to the following equation:

$$\Delta V = \sum_n \alpha_i \Delta T_i$$

where

- V is the volume measured;
- T_i is the temperature measured by the temperature transducer i;
- n is the number of temperature transducers concerned by the preparation stage.

For each stage, only the temperature of the pressure-volume controller concerned with that stage shall be considered.

7.3 Test

If the test has been performed with type B equipment, monitoring temperature in a temperature controlled room at (23 ± 1) °C, raw data shall be corrected using the coefficients calculated from the preparation tests results before flow calculation. Thus, for both cavities, the volume *V* is:

$$V = V_m - \sum_n \alpha_i \Delta T_i$$

where

- V_m is the raw volume data (measured volume);
- T_i is the temperature measured by the temperature transducer i;
- α_i is the dependence coefficient;

- n is the number of temperature transducers.

Plot a curve of the upstream and downstream volumes against time.

During the first days of the test, volume variations are not constant as detailed in 6.3. The duration of the transition state depends on the type of geosynthetic barrier and on the conditioning of the specimen.

After this period, the regime is stabilised and volume variations can be considered as constant. A linear regression of the volume variation versus time gives the average value of liquid flow from both upstream and downstream volume measurements made during the latter period which shall be greater than 7 days as previously stated.

NOTE 1 The correction of raw data of volume is not necessary if the influence of temperature on volume is small.

7.4 Test validity

Validity of the test should be examined by comparing upstream and downstream flows. Theoretically, these values should be equal, but in practice this is rarely the case for very low permeability geosynthetic barriers.

For flow rates greater than or equal to 10^{-6} $m^3/m^2/d$, values are considered as equal if the difference between them is less than 10 % of the measured flow rate on the upstream side.

In particular circumstances where testing according to the described test method indicates that values obtained for a geosynthetic barrier lies below the threshold of sensitivity of the test method then the value of liquid flow will be declared as being less than 10^{-6} m^3/m^2/day.

If the test has been carried out in a thermostatic chamber, the test is valid if the flows measured during preparation stages are less than half the flows measured during the test stage.

8 Test report

The test report shall include the following information:

a) reference number and year of publication of this European Standard, i.e. EN 14150;

b) identification of the sample, date of receipt and date of testing;

c) type of measuring device;

d) liquid used;

e) geosynthetic barrier side placed upstream (if any visible difference);

f) type of sealant (if a sealant is necessary);

g) duration of the preparation stages and the duration of the test;

h) graph of upstream and downstream volumes versus time, measured during the period of time taken into account to calculate the average value of flow using a linear regression of the volume variation as a function of time;

i) lapse of time taken into account to calculate the average values of flow;

j) average values of flow per unit area ($m^3 \cdot m^{-2} \cdot d^{-1}$) calculated from upstream and downstream volume variation measurements or an indication that the liquid flow is less than 10^{-6} m^3/m^2/day;

k) any deviation from this procedure.

Bibliography

[1] EN 25813, *Water quality — Determination of dissolved oxygen — Idometric method (ISO 5813:1983)*

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: +44 (0)20 8996 9000. Fax: +44 (0)20 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: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

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: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

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: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL