BS EN ISO 5814:2012

BSI Standards Publication

Water quality — Determination of dissolved oxygen — Electrochemical probe method (ISO 5814:2012)

National foreword

This British Standard is the UK implementation of EN ISO 5814:2012. It supersedes BS EN 25814:1992 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/3/2, Physical chemical and biochemical methods.

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

ISBN 978 0 580 66225 6

ICS 13.060.50

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2012.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 5814

October 2012

ICS 13.060.50

Supersedes EN 25814:1992

English Version

Water quality - Determination of dissolved oxygen - Electrochemical probe method (ISO 5814:2012)

Qualité de l'eau - Dosage de l'oxygène dissous - Méthode électrochimique à la sonde (ISO 5814:2012)

Wasserbeschaffenheit - Bestimmung des gelösten Sauerstoffs - Elektrochemisches Verfahren (ISO 5814:2012)

This European Standard was approved by CEN on 4 August 2012.

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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 5814:2012) has been prepared by Technical Committee ISO/TC 147 "Water quality" in collaboration with Technical Committee CEN/TC 230 "Water analysis" 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 April 2013, and conflicting national standards shall be withdrawn at the latest by April 2013.

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 supersedes EN 25814:1992.

According to the CEN/CENELEC Internal Regulations, the national standards organisations 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.

Endorsement notice

The text of ISO 5814:2012 has been approved by CEN as a EN ISO 5814:2012 without any modification.

Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5814 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 2, *Physical, chemical and biochemical methods*.

This third edition cancels and replaces the second edition (ISO 5814:1990), which has been technically revised.

The main changes compared to the second edition are:

a) a calibration procedure using water-saturated air is specified;

b) the calibration procedure using air-saturated water is omitted.

Water quality — Determination of dissolved oxygen — Electrochemical probe method

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

IMPORTANT — It is absolutely essential that tests conducted according to this International Standard be carried out by suitably trained staff.

1 Scope

This International Standard specifies an electrochemical method for the determination of dissolved oxygen in water by means of an electrochemical cell which is isolated from the sample by a gas permeable membrane.

Measurement can be made either as a concentration of oxygen in milligrams per litre, percentage saturation (% dissolved oxygen) or both. The method measures oxygen in water corresponding to 1 % to 100 % saturation. However, most instruments permit measurement of values higher than 100 %, i.e. supersaturation.

NOTE Supersaturation is possible when the partial pressure of oxygen is higher than in air. Especially when strong algal growth is present, supersaturation of up to 200 % and above can occur.

The method measures oxygen in water with a saturation higher than 100 %, when special arrangements to prevent the outgassing of oxygen during the handling and measurement of the sample are made.

The method is suitable for measurements made in the field and for continuous monitoring of dissolved oxygen, as well as measurements made in the laboratory. It is the preferred method for highly coloured and turbid waters, and also for analysis of waters not suitable for the Winkler titration method because of iron- and iodine-fixing substances, which can interfere in the iodometric method specified in ISO 5813[1].

The method is suitable for drinking waters, natural waters, waste waters, and saline waters. If used for saline waters, such as sea or estuarine waters, a correction for salinity is essential.

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.

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

3 Principle

Immersion of a probe, consisting of a cell enclosed by a selective membrane and containing the electrolyte and at least two metallic electrodes, in the water to be analysed.

NOTE The membrane is effectively impermeable to water and ionic dissolved matter, but is permeable to oxygen and a certain number of other gases.

One of the electrodes is made of a noble metal like gold or platinum. Oxygen is reduced at its surface by an electrochemical process. In order to make this process possible, a suitable electrochemical potential is established at this electrode. For polarographic probes, this is achieved by applying an external voltage related to a second electrode. Galvanic probes are able to build up the potential by themselves.

The current resulting from the reduction of oxygen is directly proportional to the rate of transport of oxygen through the membrane and the layer of electrolyte, and hence to the partial pressure of the oxygen in the sample at a given temperature.

Temperature has two different influences. The first relates to the variation of gas permeability of the membrane with temperature. So the primary signal of the probe has to be compensated with a built-in temperature sensor. Meters manufactured recently are able to do this automatically. The second is the temperature effect on the electrode reactions.

To calculate the percentage of saturation of samples in contact with an atmosphere, it is necessary to include the effective pressure. This can be performed manually or by implementing a pressure sensor for automatic compensation. Salinity can also be an influence.

4 Interferences

Gases and vapors such as chlorine, hydrogen sulfide, amines, ammonia, bromine, and iodine which diffuse through the membrane can interfere, if present, by affecting the measured current.

Other substances present in the sample can interfere with the measured current by causing obstruction, deterioration of the membrane or corrosion of the electrodes. These include solvents, oils, sulfides, carbonates, and biofilms.

5 Reagents

During analysis, use only reagents of recognized analytical grade.

5.1 **Water**, grade 2, as specified in ISO 3696, optionally from commercial sources.

5.2 **Sodium sulfite**, anhydrous, Na_2SO_3 or heptahydrate, $Na_2SO_3 \cdot 7H_2O$.

5.3 **Cobalt(II) salt**, for example cobalt(II) chloride hexahydrate, $CoCl_2 \cdot 6H_2O$.

5.4 **Nitrogen gas,** N_2, purity 99,995 % volume fraction or better.

6 Apparatus

6.1 **Measuring instrument**, comprising the components specified in 6.1.1 and 6.1.2.

6.1.1 **Measuring probe**, either of the galvanic type (e.g. lead/silver) or the polarographic type (e.g. silver/gold) with, if required, a temperature-sensitive compensating device.

6.1.2 **Meter**, graduated to show the concentrations of dissolved oxygen directly, and/or percentage saturation with oxygen.

6.2 **Thermometer**, graduated in at least 0,5 °C divisions.

NOTE Commonly a temperature sensor is integrated into the instrument (6.1).

6.3 **Barometer**, graduated to 1 hPa.

NOTE Usually the barometer is integrated into the instrument (6.1).

7 Sampling and analysis procedure

7.1 Sampling

7.1.1 General

Samples should always be handled so that transfer of oxygen between water sample and air is inhibited.

As a matter of principle, the oxygen concentration shall be measured directly on site in the water body to be analysed.

If direct measurement in the water body is not possible, the measurement can also be taken in a gas-tight connected flow-through device or immediately after sampling as a discrete sample.

Any discrete sampling procedure results in a higher measurement uncertainty.

While filling the sample vessel during sampling, oxygen uptake or oxygen stripping shall be minimized. Sample transfer shall occur without any turbulence, i.e. by maintaining a laminar flow.

7.1.2 Dip-sampling (e.g. surface waters)

Take the sample by carefully and slowly dipping the sample vessel.

7.1.3 Sampling from taps

Connect an inert sampling tube, in a gas-tight fashion, to the tap and insert the sampling tube all the way down to the bottom of the sampling vessel. Ensure that the volume of water allowed to overflow is at least three times the capacity of the vessel.

7.1.4 Sampling with pumps

Only water-displacing submersible pumps should be used. Pumps that function according to the principle of air displacement are *not* suitable. Fill the sample vessel from the bottom, using a sampling tube, and allow the water to overflow. During sample transfer, the volume flow rate shall be controlled in order to guarantee a mainly laminar flow. Ensure that the volume of water allowed to overflow is at least three times the capacity of the vessel.

7.2 Measuring technique and precautions to be taken

The measuring system shall be in a proper state as specified in the manufacturer’s instructions. For example:

- ensure the membrane is not damaged;
- allow an adequate polarization time;
- calibrate the system when necessary.

When a measurement is performed, ensure that the sample flows past the membrane with sufficient velocity according to the manufacturer’s instructions. This can be achieved by natural streaming, movement of the sensor or stirring, e.g. with a magnetic stirrer. This is necessary to prevent loss of signal because of consumption of oxygen by the sensor.

Take care that there is no exchange of oxygen from a gas reservoir to the sample or vice versa. Therefore, avoid formation of any air bubbles in the samples that are measured in a vessel. When measuring on-site, do not generate any air bubbles, which may affect the signal.

For storing and maintenance of the probe, consult the manufacturer’s instructions.

7.3 Calibration

7.3.1 General

The procedure is described in 7.3.2 to 7.3.3, but it is also necessary to consult the manufacturer's instructions.

Calibration at air saturation should be checked daily and after relevant changes of ambient conditions (i.e. temperature or pressure).

7.3.2 Checking the zero

If necessary check and if possible adjust the zero setting of the instrument by immersing the probe in 1 l of water to which the equivalent of 1 g or more of sodium sulfite (5.2) and about 1 mg of cobalt(II) salt (5.3) have been added to render the water free from oxygen. The solution is usable after an adequate reaction time.

Modern probes typically achieve a stable response within 10 min to 15 min. However, different probes can have different response rates and the manufacturer's instructions should be consulted.

NOTE Cobalt(II) is used as catalyst for the reduction of oxygen by the sulfite. The zero checking and setting, if possible, can also be performed in a pure nitrogen atmosphere.

7.3.3 Calibration at saturation

Perform the calibration in an applicable container according to manufacturer's instructions. Simple and effective calibration is possible in water vapour-saturated air.

NOTE 1 There are small differences between sensor currents in water and in air. Because of the sensor geometry, in water a so-called unmoved diffusion layer exists, which leads to a signal depression of ~2 %. Therefore, the calibration target is 102 % in water vapour-saturated air (refer to the manufacturer's instructions). This is commensurate with 100 % saturation in water.

Replace the electrolyte and/or the membrane when the instrument can no longer be calibrated or when the response becomes unstable or slow (see the manufacturer's instructions).

NOTE 2 Values can be checked by the Winkler titration (see ISO 5813[1]).

7.3.4 Linearity check

A linearity check (carried out in the laboratory versus Winkler test) is only necessary if there is a problem with the instrument. In that case, consult the manufacturer's instructions.

7.4 Determination

Carry out the determination on the water to be analysed according to the manufacturer's instructions.

Ensure sufficient agitation of the water (see 7.2).

Completely immerse the measuring probe sensor in the sample, allowing an intensive contact of the membrane and the temperature sensor with the water.

Check the influencing variables, namely sample temperature, atmospheric pressure, and salinity of the sample.

NOTE Most instruments compensate for the temperature behaviour of the probe and take into account the atmospheric pressure for the computation of the final reading. When using instruments without these automatic functions the influence of temperature and pressure have to be considered by the user. For information on how the solubility of oxygen is dependent on temperature, pressure and salinity, and for the correlation between conductivity and salinity, see Annex A.

8 Calculation and expression of results

8.1 Dissolved oxygen concentration

Express the dissolved oxygen concentration, in milligrams of oxygen per litre, and report the result to the first decimal place.

EXAMPLE 1 $\rho_{O_2} = 1{,}5\ \text{mg/l}$.

EXAMPLE 2 $\rho_{O_2} = 18{,}1\ \text{mg/l}$.

8.2 Dissolved oxygen expressed as percentage saturation

Most instruments are equipped with an automatic calculation. If required, calculate the percentage saturation of dissolved oxygen in water, expressed as a percentage, w_{O_2}, from

$$w_{O_2} = \frac{\rho_{O_2}}{\rho_{O_2,s}} \times 100 \tag{1}$$

where

ρ_{O_2} is the actual concentration, expressed in milligrams per litre, mg/l, of dissolved oxygen found in a water sample at an atmospheric pressure, p, in hectopascals, hPa, at a water temperature, θ, in degrees Celsius, °C;

$\rho_{O_2,s}$ is the theoretical concentration, expressed in milligrams per litre, mg/l, of oxygen for that sample at the atmospheric pressure, p, and the temperature, θ, if the sample were saturated with moist air (solubility, see Annex A).

Report the result to the nearest whole number. Give the water temperature θ and atmospheric pressure p at the measurement, and salinity S of the sample, if the latter has been taken into account.

EXAMPLE 1

$w_{O_2} = 3\ \%$ $p = 1\ 115$ hPa; $\theta = 19{,}5$ °C; $S = 35$

EXAMPLE 2

$w_{O_2} = 104\ \%$ $p = 1\ 005$ hPa; $\theta = 22{,}1$ °C; $S = 3$

9 Test report

The test report shall contain at least the following information:

a) the test method used, together with a reference to this International Standard (ISO 5814:2012);

b) the identity of the water sample;

c) the measuring conditions:

  — the temperature of the water when the sample was taken and when the measurement was carried out,

  — the atmospheric pressure when the sample was taken and when the measurement was carried out,

  — the salinity of the water;

d) the result in accordance with Clause 8;

e) all circumstances that might have influenced the result.

Annex A
(informative)

Physicochemical data for oxygen in water

A.1 Salinity and conductivity

Use the values in Table A.1 if the conductivity meter in use does not measure salinity. Use a conductivity meter to determine conductivity at reference temperature (20 °C), then use Table A.1 to estimate the salinity to the nearest whole number.

If the conductivity meter is only able to display the conductivity at another reference temperature, the conductivity at 20 °C has to be calculated by a correction factor (see ISO 7888[2]).

Table A.1 was calculated up to the conductivity of 5,4 S/m from the *International oceanographic tables* (see Reference [7]).

Table A.1 — Correlation conductivity–salinity

Conductivity S/m [b]	Salinity value[a]	Conductivity S/m [b]	Salinity value[a]	Conductivity S/m [b]	Salinity value[a]
0,5	3	2,0	13	3,5	25
0,6	4	2,1	14	3,6	25
0,7	4	2,2	15	3,7	26
0,8	5	2,3	15	3,8	27
0,9	6	2,4	16	3,9	28
1,0	6	2,5	17	4,0	29
1,1	7	2,6	18	4,2	30
1,2	8	2,7	18	4,4	32
1,3	8	2,8	19	4,6	33
1,4	9	2,9	20	4,8	35
1,5	10	3,0	21	5,0	37
1,6	10	3,1	22	5,2	38
1,7	11	3,2	22	5,4	40
1,8	12	3,3	23	—	—
1,9	13	3,4	24	—	—

[a] Salinity determined from conductivity at 20 °C.

[b] 1 S/m = 10 mmhos/cm.

A.2 Atmospheric pressure and elevation

Table A.2 is used to estimate the true atmospheric pressure at certain elevations. The correspondence is based on the assumption that at sea level the atmospheric pressure is 1 013 hPa. After taking the atmospheric pressure depending on the elevation from Table A.2 or more precisely from a local weather service, enter this value into the instrument.

NOTE 1 The values given in Table A.2 are approximations derived according to the international atmospheric formula and can differ from other data obtained from other feasible equations.

NOTE 2 Corrections of the atmospheric pressure are only necessary if the instrument does not do this automatically.

Table A.2 — Elevation atmospheric pressure (example)

Elevation m	Atmospheric pressure hPa	Elevation m	Atmospheric pressure hPa
0	1 013	1 800	815
150	995	1 950	800
300	979	2 100	785
450	960	2 250	771
600	943	2 400	756
750	926	2 550	742
900	910	2 700	728
1 050	893	2 850	715
1 200	877	3 000	701
1 350	861	3 150	688
1 500	846	3 300	675
1 650	830	—	—

A.3 Solubility of oxygen in water

Table A.3 — Solubility of oxygen in water equilibrated with water-saturated air at atmospheric pressure (1 013 hPa) (for salinity see Table A.1)

Temperature °C	Salinity				
	0	9	18	27	36
	Oxygen solubility mg/l				
0	14,62	13,73	12,89	12,11	11,37
1,0	14,22	13,36	12,55	11,79	11,08
2,0	13,83	13,00	12,22	11,49	10,80
3,0	13,46	12,66	11,91	11,20	10,54
4,0	13,11	12,34	11,61	10,93	10,28
5,0	12,77	12,03	11,33	10,66	10,04
6,0	12,45	11,73	11,05	10,41	9,81
7,0	12,14	11,44	10,79	10,17	9,58
8,0	11,84	11,17	10,54	9,94	9,37
9,0	11,56	10,91	10,29	9,71	9,16
10,0	11,29	10,66	10,06	9,50	8,97
11,0	11,03	10,42	9,84	9,29	8,78
12,0	10,78	10,19	9,63	9,09	8,59
13,0	10,54	9,96	9,42	8,90	8,42
14,0	10,31	9,75	9,22	8,72	8,25
15,0	10,08	9,54	9,03	8,55	8,09
16,0	9,87	9,35	8,85	8,38	7,93
17,0	9,67	9,15	8,67	8,21	7,78
18,0	9,47	8,97	8,50	8,05	7,63
19,0	9,28	8,79	8,34	7,90	7,49

Table A.3 *(continued)*

Temperature	Salinity				
	0	**9**	**18**	**27**	**36**
°C	**Oxygen solubility** mg/l				
20,0	9,09	8,62	8,18	7,75	7,35
21,0	8,92	8,46	8,02	7,61	7,22
22,0	8,74	8,30	7,88	7,47	7,09
23,0	8,58	8,14	7,73	7,34	6,97
24,0	8,42	8,00	7,59	7,21	6,85
25,0	8,26	7,85	7,46	7,09	6,73
26,0	8,11	7,71	7,33	6,97	6,62
27,0	7,97	7,58	7,20	6,85	6,51
28,0	7,83	7,45	7,08	6,73	6,40
29,0	7,69	7,32	6,96	6,62	6,30
30,0	7,56	7,20	6,85	6,52	6,20
31,0	7,43	7,07	6,74	6,41	6,10
32,0	7,31	6,96	6,63	6,31	6,01
33,0	7,18	6,84	6,52	6,21	5,92
34,0	7,07	6,73	6,42	6,11	5,83
35,0	6,95	6,63	6,32	6,02	5,74
36,0	6,84	6,52	6,22	5,93	5,65
37,0	6,73	6,42	6,12	5,84	5,57
38,0	6,62	6,32	6,03	5,75	5,48
39,0	6,52	6,22	5,93	5,66	6,40
40,0	6,41	6,12	5,84	5,58	5,32
41,0	6,31	6,03	5,75	5,50	5,25
42,0	6,21	5,94	5,67	5,41	5,17
43,0	6,12	5,84	5,58	5,33	5,09
44,0	6,02	5,75	5,50	5,25	5,02
45,0	5,93	5,67	5,42	5,18	4,95

EXAMPLE

Temperature at measurement	20 °C
Measured conductivity	0,87 S/m (20 °C)
Salinity (Table A.1)	6
Oxygen solubility (20 °C), salinity: 0 (Table A.3)	9,09 mg/l
Oxygen solubility (20 °C), salinity: 9 (Table A.3)	8,62 mg/l
Increment	(9,09 mg/l − 8,62 mg/l)/9 = 0,052 2 mg/l
Oxygen solubility at given salinity	9,09 mg/l − (0,052 2 mg/l × 6) = 8,8 mg/l

Table A.4 — Solubility of oxygen in water vs. temperature and atmospheric pressure (lower range)

Temperature °C	**Pressure** hPa						
	733	**767**	**800**	**833**	**867**	**900**	**933**
	Oxygen solubility mg/l						
0	10,56	11,04	11,53	12,01	12,49	12,98	13,46
1	10,27	10,74	11,21	11,68	12,15	12,62	13,09
2	9,98	10,44	10,90	11,36	11,82	12,27	12,73
3	9,72	10,16	10,61	11,05	11,50	11,94	12,39
4	9,46	9,89	10,33	10,76	11,20	11,63	12,06
5	9,21	9,64	10,06	10,48	10,91	11,33	11,75
6	8,98	9,39	9,80	10,22	10,63	11,04	11,46
7	8,75	9,16	9,56	9,96	10,37	10,77	11,17
8	8,54	8,93	9,33	9,72	10,11	10,51	10,90
9	8,33	8,72	9,10	9,48	9,87	10,25	10,64
10	8,13	8,51	8,88	9,26	9,64	10,01	10,39
11	7,94	8,31	8,68	9,04	9,41	9,78	10,15
12	7,76	8,12	8,48	8,84	9,20	9,56	9,92
13	7,58	7,94	8,29	8,64	8,99	9,34	9,69
14	7,41	7,76	8,10	8,45	8,79	9,14	9,48
15	7,25	7,59	7,93	8,26	8,60	8,94	9,28
16	7,10	7,43	7,76	8,09	8,42	8,75	9,08
17	6,94	7,27	7,59	7,92	8,24	8,56	8,89
18	6,80	7,12	7,43	7,75	8,07	8,39	8,70
19	6,66	6,97	7,28	7,59	7,91	8,22	8,53
20	6,52	6,83	7,13	7,44	7,75	8,05	8,36
21	6,39	6,69	6,99	7,29	7,59	7,89	8,19
22	6,26	6,56	6,85	7,15	7,45	7,74	8,04
23	6,14	6,43	6,72	7,01	7,30	7,59	7,88
24	6,02	6,31	6,59	6,88	7,16	7,45	7,73
25	5,91	6,19	6,47	6,75	7,03	7,31	7,59
26	5,80	6,07	6,35	6,62	6,90	7,18	7,45
27	5,69	5,96	6,23	6,50	6,77	7,05	7,32
28	5,58	5,85	6,12	6,38	6,65	6,92	7,19
29	5,48	5,74	6,01	6,27	6,53	6,80	7,06
30	5,38	5,64	5,90	6,16	6,42	6,68	6,94
31	5,28	5,54	5,80	6,05	6,31	6,56	6,82
32	5,19	5,44	5,69	5,95	6,20	6,45	6,70
33	5,10	5,35	5,59	5,84	6,09	6,34	6,59
34	5,01	5,25	5,50	5,74	5,99	6,23	6,48
35	4,92	5,16	5,40	5,64	5,89	6,13	6,37
36	4,83	5,07	5,31	5,55	5,79	6,03	6,26
37	4,75	4,98	5,22	5,46	5,69	5,93	6,16
38	4,67	4,90	5,13	5,36	5,60	5,83	6,06
39	4,58	4,81	5,04	5,27	5,50	5,73	5,96

Table A.4 *(continued)*

Temperature °C	Pressure hPa						
	733	**767**	**800**	**833**	**867**	**900**	**933**
	Oxygen solubility mg/l						
40	4,50	4,73	4,96	5,19	5,41	5,64	5,87
41	4,43	4,65	4,88	5,10	5,32	5,55	5,77
42	4,35	4,57	4,79	5,01	5,24	5,46	5,68
43	4,27	4,49	4,71	4,93	5,15	5,37	5,59
44	4,20	4,41	4,63	4,85	5,07	5,28	5,50
45	4,12	4,34	4,55	4,77	4,98	5,20	5,41

Table A.5 — Solubility of oxygen in water vs. temperature and atmospheric pressure (upper range)

Temperature °C	Pressure hPa						
	967	**1 000**	**1 013**	**1 033**	**1 066**	**1 100**	**1 133**
	Oxygen solubility mg/l						
0	13,94	14,43	14,62	14,91	15,39	15,88	16,36
1	13,56	14,03	14,22	14,50	14,97	15,44	15,91
2	13,19	13,65	13,83	14,10	14,56	15,02	15,48
3	12,84	13,28	13,46	13,73	14,17	14,62	15,06
4	12,50	12,93	13,11	13,37	13,80	14,24	14,67
5	12,18	12,60	12,77	13,02	13,45	13,87	14,29
6	11,87	12,28	12,45	12,69	13,11	13,52	13,93
7	11,57	11,98	12,14	12,38	12,78	13,19	13,59
8	11,29	11,69	11,84	12,08	12,47	12,87	13,26
9	11,02	11,41	11,56	11,79	12,17	12,56	12,94
10	10,76	11,14	11,29	11,51	11,89	12,26	12,64
11	10,51	10,88	11,03	11,25	11,61	11,98	12,35
12	10,27	10,63	10,78	10,99	11,35	11,71	12,07
13	10,04	10,40	10,54	10,75	11,10	11,45	11,80
14	9,82	10,17	10,31	10,51	10,86	11,20	11,54
15	9,61	9,95	10,08	10,29	10,62	10,96	11,30
16	9,41	9,74	9,87	10,07	10,40	10,73	11,06
17	9,21	9,54	9,67	9,86	10,18	10,51	10,83
18	9,02	9,34	9,47	9,66	9,98	10,29	10,61
19	8,84	9,15	9,28	9,46	9,77	10,09	10,40
20	8,66	8,97	9,09	9,28	9,58	9,89	10,19
21	8,49	8,79	8,92	9,10	9,40	9,70	10,00
22	8,33	8,63	8,74	8,92	9,21	9,51	9,80
23	8,17	8,46	8,58	8,75	9,04	9,33	9,62
24	8,02	8,30	8,42	8,59	8,87	9,16	9,44
25	7,87	8,15	8,26	8,43	8,71	8,99	9,27

Table A.5 *(continued)*

Temperature °C	**Pressure** hPa						
	967	**1 000**	**1 013**	**1 033**	**1 066**	**1 100**	**1 133**
	Oxygen solubility mg/l						
26	7,73	8,00	8,11	8,28	8,55	8,83	9,11
27	7,59	7,86	7,97	8,13	8,40	8,67	8,94
28	7,45	7,72	7,83	7,99	8,25	8,52	8,79
29	7,32	7,59	7,69	7,85	8,11	8,37	8,64
30	7,20	7,46	7,56	7,71	7,97	8,23	8,49
31	7,07	7,33	7,43	7,58	7,84	8,09	8,35
32	6,95	7,20	7,31	7,46	7,71	7,96	8,21
33	6,84	7,08	7,18	7,33	7,58	7,83	8,08
34	6,72	6,97	7,07	7,21	7,46	7,70	7,95
35	6,61	6,85	6,95	7,09	7,34	7,58	7,82
36	6,50	6,74	6,84	6,98	7,22	7,46	7,70
37	6,40	6,63	6,73	6,87	7,10	7,34	7,57
38	6,29	6,53	6,62	6,76	6,99	7,22	7,46
39	6,19	6,42	6,52	6,65	6,88	7,11	7,34
40	6,09	6,32	6,41	6,55	6,78	7,00	7,23
41	6,00	6,22	6,31	6,45	6,67	6,90	7,12
42	5,90	6,12	6,21	6,35	6,57	6,79	7,01
43	5,81	6,03	6,12	6,25	6,47	6,69	6,91

A.4 Pressure conversions

Refer to Table A.6 for pressure conversions by the given conversion factors.

Table A.6 — Pressure conversions

Unit	mbar	mmHg	Inches Hg
1 hPa	1	0,750 06	0,029 53
1 mbar	1	0,750 06	0,029 53
1 mmHg	1,333 2	1	0,0393 70
1 inch Hg	33,864	25,400	1

EXAMPLE

To convert 1 013,25 mbar into inches Hg, multiply 1 013,25 by 0,029 53. The result is 29,92 inches Hg.

To convert 1 013,25 mbar into mmHg, multiply 1 013,25 by 0,750 06. The result is 760 mmHg.

Annex B
(informative)

Performance data

An interlaboratory trial for the validation of ISO 5814 was carried out in Spring 2011. The results are given in Table B.1.

Table B.1 — Performance data

Sample	Matrix	Parameter	l	n	o	$\bar{\bar{x}}$ mg/l	X mg/l	η %	s_R mg/l	$C_{V,R}$ %	s_r mg/l	$C_{V,r}$ %
1	Drinking water 13 °C	Oxygen	18	54	10,0	10,49	10,57	99,2	0,319	3,0	0,137	1,3
2	Drinking water room temperature	Oxygen	17	50	15,3	8,99	9,11	98,7	0,363	4,0	0,054	0,6
3	Drinking water 30 °C	Oxygen	19	56	5,1	7,68	7,67	100,1	0,512	6,7	0,073	0,9
4	Drinking water deaerated	Oxygen	16	48	11,1	0,18	—	—	0,139	79,4	0,039	22,0
5	Model sewage plant	Oxygen	16	48	20,0	4,10	—	—	0,856	20,9	0,073	1,8
6	River water	Oxygen	17	50	15,3	9,00	—	—	0,638	7,1	0,050	0,6
7	Salinity 8	Oxygen	17	51	15,0	9,11	—	—	0,673	7,4	0,073	0,8
8	Salinity 35	Oxygen	18	54	10,0	8,96	—	—	0,653	7,3	0,047	0,5
l	number of laboratories after outlier rejection											
n	number of individual results after outlier rejection											
o	percentage of outliers											
$\bar{\bar{x}}$	overall mean of results (without outliers)											
X	assigned value											
η	recovery rate											
s_R	reproducibility standard deviation											
$C_{V,R}$	coefficient of variation of reproducibility											
s_r	repeatability standard deviation											
$C_{V,r}$	coefficient of variation of repeatability											

Bibliography

[1] ISO 5813, *Water quality — Determination of dissolved oxygen — Iodometric method*

[2] ISO 7888, *Water quality — Determination of electrical conductivity*

[3] Dissolved oxygen documents and their references can be found in *Standard methods for the examination of water and wastewater*, 2012, 22nd edition, Chapter 4500-O

[4] BENSON, B.B, KRAUSE, D. Jr. The concentration and isotopic fractionation of gases dissolved in fresh water in equilibrium with the atmosphere: I. Oxygen. *Limnol. Oceanogr*. 1980, **25**, pp. 662–671

[5] MORTIMER, C.H. 1981. *The oxygen content of air-saturated fresh waters over ranges of temperature and atmospheric pressure of limnological interest*. Stuttgart: Schweizerbart, 1981. 23 p. (*Communications of the International Association for Theoretical and Applied Limnology*, No. 22.)

[6] BENSON, B.B., KRAUSE, D. Jr. The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere. *Limnol. Oceanogr*. 1984, **29**, pp. 620–632

[7] UNESCO INSTITUTE OF OCEANOGRAPHIC SCIENCES. *International oceanographic tables*, Vol. 1. Paris: UNESCO, 1971

This page deliberately left blank

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.

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

All the data, software and documentation set out in all British Standards and other BSI publications are the property of and copyrighted by BSI, or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use. 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. Details and advice can be obtained from the Copyright & Licensing Department.

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 Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™