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# International Standard



# 5813

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## Water quality — Determination of dissolved oxygen — Iodometric method

*Qualité de l'eau — Dosage de l'oxygène dissous — Méthode iodométrique*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5813 was developed by Technical Committee ISO/TC 147, *Water quality*, and was circulated to the member bodies in July 1982.

It has been approved by the member bodies of the following countries:

Australia	Germany, F.R.	Poland
Austria	Hungary	Romania
Belgium	India	South Africa, Rep. of
Canada	Iran	Spain
Chile	Iraq	Sweden
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Czechoslovakia	Japan	Thailand
Denmark	Korea, Rep. of	United Kingdom
Egypt, Arab Rep. of	Mexico	USA
Finland	Netherlands	USSR
France	Norway	

No member body expressed disapproval of the document.

# Water quality — Determination of dissolved oxygen — Iodometric method

## 1 Scope and field of application

This International Standard specifies an iodometric method for the determination of dissolved oxygen in water by the so-called "Winkler procedure" modified in order to make allowance for certain interferences.

The iodometric method is the reference method for the determination of dissolved oxygen in water. It is applicable to all types of water having dissolved oxygen concentrations greater than 0,2 mg/l, up to double saturation of oxygen (approximately 20 mg/l), which are free from interfering substances. Readily oxidizable organic substances such as tannins, humic acid and lignins, interfere. Oxidizable sulphur compounds such as sulphides and thiourea also interfere, as do actively respiring systems which readily consume oxygen. In the presence of such substances, it is preferable to use the electrochemical probe method specified in ISO 5814.

Nitrites up to a concentration of 15 mg/l do not interfere with the determination because they are destroyed by the addition of sodium azide.

If oxidizing or reducing substances are present, it is necessary to make modifications to the method; these are described in clause 9.

If suspended matter, capable of fixing or consuming iodine, is present, the method may be used with the modification described in the annex, but it is preferable to use the electrochemical probe method.

## 2 Reference

ISO 5814, *Water quality — Determination of dissolved oxygen — Electrochemical probe method.*<sup>1)</sup>

## 3 Principle

Reaction of dissolved oxygen in the sample with freshly precipitated manganese(II) hydroxide [formed by the addition of sodium or potassium hydroxide to manganese(II) sulphate]. Acidification, and oxidation of iodide by the higher valency manganese compound so formed, liberating an equivalent

quantity of iodine. Determination of the quantity of iodine liberated by titration with sodium thiosulphate.

## 4 Reagents

During the analysis, use only reagents of recognized analytical grade and only distilled water or water of equivalent purity.

### 4.1 Sulphuric acid, solution.<sup>2)</sup>

Cautiously add 500 ml of concentrated sulphuric acid ( $\rho = 1,84$  g/ml) to 500 ml water, stirring continuously.

### 4.2 Sulphuric acid, solution, $c(1/2 \text{H}_2\text{SO}_4) = 2$ mol/l.

### 4.3 Alkaline iodide-azide reagent.

**WARNING — Sodium azide is an extremely strong poison. If nitrites are known to be absent, this reagent may be omitted.**

Dissolve 35 g of sodium hydroxide (NaOH) [or 50 g of potassium hydroxide (KOH)] and 30 g of potassium iodide (KI) [or 27 g of sodium iodide (NaI)] in approximately 50 ml of water.

Dissolve separately 1 g of sodium azide ( $\text{NaN}_3$ ) in a few millilitres of water.

Mix the two solutions and dilute to 100 ml.

Store the solution in a stoppered, brown glass flask.

After dilution and acidification, this reagent should not show any colour in the presence of the indicator solution (4.7).

### 4.4 Manganese(II) sulphate anhydrous, 340 g/l solution (or manganese sulphate monohydrate, 380 g/l solution).

Alternatively, use manganese(II) chloride tetrahydrate, 450 g/l solution.

Filter any solution which is not clear.

1) At present at the stage of draft.

2) If the presence of trivalent iron is suspected, use phosphoric acid ( $\text{H}_3\text{PO}_4$ ),  $\rho = 1,70$  g/ml.

**4.5 Potassium iodate**,  $c(1/6 \text{ KIO}_3) = 10 \text{ mmol/l}$ , standard solution.

Dry a few grams of potassium iodate ( $\text{KIO}_3$ ) at  $180 \text{ }^\circ\text{C}$ . Weigh  $3,567 \pm 0,003 \text{ g}$  and dissolve in water. Dilute to  $1\ 000 \text{ ml}$ .

Withdraw  $100 \text{ ml}$  and dilute with water to  $1\ 000 \text{ ml}$  in a volumetric flask.

**4.6 Sodium thiosulphate**, standard volumetric solution,  $c(\text{Na}_2\text{S}_2\text{O}_3) \approx 10 \text{ mmol/l}$ .

#### 4.6.1 Preparation

Dissolve  $2,5 \text{ g}$  of sodium thiosulphate pentahydrate ( $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ ) in freshly boiled and cooled water. Add  $0,4 \text{ g}$  of sodium hydroxide ( $\text{NaOH}$ ) and dilute to  $1\ 000 \text{ ml}$ .

Store the solution in a dark glass bottle.

#### 4.6.2 Standardization

Dissolve, in a conical flask, approximately  $0,5 \text{ g}$  of potassium or sodium iodide ( $\text{KI}$  or  $\text{NaI}$ ) in  $100$  to  $150 \text{ ml}$  water. Add  $5 \text{ ml}$  of  $2 \text{ mol/l}$  sulphuric acid solution (4.2).

Mix and add  $20,00 \text{ ml}$  of the standard potassium iodate solution (4.5). Dilute to about  $200 \text{ ml}$  and immediately titrate the liberated iodine with the sodium thiosulphate solution, adding the indicator solution (4.7) towards the end of the titration, when a pale straw colour is reached, and then titrating until complete decoloration.

The concentration  $c$ , expressed in millimoles per litre, is given by the equation

$$c = \frac{6 \times 20 \times 1,66}{V}$$

where  $V$  is the volume, in millilitres, of sodium thiosulphate solution used for the titration.

Standardize the solution daily.

**4.7 Starch**, freshly prepared  $10 \text{ g/l}$  solution.

NOTE — Other suitable indicators may be used.

**4.8 Phenolphthalein**,  $1 \text{ g/l}$  ethanolic solution.

**4.9 Iodine**, approximately  $0,005 \text{ mol/l}$  solution.

Dissolve  $4$  to  $5 \text{ g}$  of potassium or sodium iodide in a little water and add approximately  $130 \text{ mg}$  of iodine. After dissolution of the iodine, dilute to  $100 \text{ ml}$ .

**4.10 Potassium iodide or sodium iodide.**

## 5 Apparatus

Ordinary laboratory equipment, and

**5.1 Narrow-mouthed glass flasks**, of capacity between  $130$  and  $350 \text{ ml}$ , calibrated to the nearest  $1 \text{ ml}$ , with stoppers (Winkler flasks, or any other suitable flasks, preferably with straight shoulders). Each flask and its stopper shall bear the same identification number. The volume of each flask may be determined by weighing.

## 6 Procedure

**6.1** In the presence of suspended matter capable of fixing or consuming iodine, or if in doubt about the presence of such matter, proceed as described in the annex or, preferably, determine dissolved oxygen by the electrochemical probe method specified in ISO 5814.

### 6.2 Check for the presence of oxidizing or reducing substances

If oxidizing or reducing agents can be expected to interfere with the results, collect  $50 \text{ ml}$  of the water to be analysed and neutralize it in the presence of  $2$  drops of the phenolphthalein solution (4.8). Add  $0,5 \text{ ml}$  of the sulphuric acid solution (4.2), a few crystals (of mass approximately  $0,5 \text{ g}$ ) of the potassium or sodium iodide (4.10) and a few drops of the indicator solution (4.7).

If the solution turns blue, oxidizing substances are present.

If the solution stays colourless, add  $0,2 \text{ ml}$  of the iodine solution (4.9) and shake. Leave for  $30 \text{ s}$ . If no blue colour appears, reducing substances are present.<sup>1)</sup>

In the presence of oxidizing substances, proceed as specified in 9.1.

In the presence of reducing substances, proceed as specified in 9.2.

In the absence of oxidizing or reducing substances, proceed as specified in 6.3, 6.4 and 6.5.

### 6.3 Collection of samples

Unless it is essential to proceed otherwise, collect the sample in the flask (5.1) in which the determination is to be made.

The test sample consists of all the contents of the filled flask.

NOTE — In the presence of oxidizing or reducing substances, it is necessary to take a second test sample (see 9.1.2.1 and 9.2.3.1).

1) Further addition of iodine solution permits evaluation of the volume of sodium hypochlorite solution to be added in 9.2.3.

### 6.3.1 Sampling surface waters

Fill the flask (5.1) to overflowing, taking care to avoid any change in the concentration of dissolved oxygen.

For shallow waters, it is preferable to use the electrochemical probe method.

After elimination of any air bubbles that may be adhering to the glass, immediately fix the dissolved oxygen (see 6.4).

### 6.3.2 Sampling water from distribution pipelines

Connect a tube of inert material to the inlet and extend the tube outlet to the bottom of the flask (5.1).

Fill the flask by flushing it with a volume of water which is about ten times the volume of the flask. After elimination of any air bubbles that may be adhering to the glass, immediately fix the dissolved oxygen (see 6.4).

### 6.3.3 Sampling water at varying depths

Use a special sampler, containing the flask (5.1), equipped with a rubber inlet tube extending to the bottom of the flask.

The flask is filled by air displacement. Avoid turbulence. Certain types of samplers permit filling of several flasks at the same time.

## 6.4 Fixing of oxygen

After the sample has been taken, preferably on site, immediately add to the flask, containing the sample, 1 ml of the manganese(II) sulphate solution (4.4) and 2 ml of the alkaline reagent (4.3). Add reagents below the surface using narrow tipped pipettes. Replace the stopper carefully to avoid the inclusion of air bubbles.

If some other system is used, take the precautions necessary to ensure that the oxygen content of the sample is not modified.

Turn the flask upside down several times to mix the contents thoroughly. Allow the precipitate which is formed to settle for at least 5 min and then mix by inversion again to ensure that the mixture is homogeneous.

The flask may then be transported to the laboratory.

If protected from light, the sample may be stored for up to 24 h.

## 6.5 Liberation of iodine

Ensure that the precipitate which has been formed has settled so that it is in the lower third of the flask.

Add slowly 1,5 ml of the sulphuric acid solution (4.1) [or the corresponding volume of the phosphoric acid solution (see the

footnote to 4.1)], stopper the flask, then shake until all the precipitate has been dissolved and the iodine is evenly distributed.

NOTE — If the titration is to be carried out directly in the flask, a corresponding portion of the clear, supernatant liquid should be cautiously siphoned off without whirling up the sediment.

## 6.6 Titration

Transfer the contents of the flask or of an aliquot portion (volume  $V_1$ ) to a conical flask.

Titrate with the sodium thiosulphate solution (4.6), using either the starch solution (4.7), added near the end of the titration, or another suitable indicator.

## 7 Expression of results

The dissolved oxygen content, expressed in milligrams of oxygen per litre, is given by the formula

$$\frac{M_r V_2 c f_1}{4 V_1}$$

where

$M_r$  is the relative molecular mass of oxygen ( $M_r = 32$ );

$V_1$  is the volume, in millilitres, of the test sample or the aliquot portion ( $V_1 = V_0$  if all the contents of the flask were titrated);

$V_2$  is the volume, in millilitres, of sodium thiosulphate solution (4.6) used to titrate the contents of the flask or the aliquot portion;

$c$  is the actual concentration, expressed in millimoles per litre, of the sodium thiosulphate solution (4.6);

$$f_1 = \frac{V_0}{V_0 - V'}$$

where

$V_0$  is the volume, in millilitres, of the flask (5.1),

$V'$  is the sum of the volumes of the manganese(II) sulphate solution (4.4) (1 ml) and the alkaline reagent (4.3) (2 ml).

Report the result to one decimal place.

## 8 Reproducibility

Replicate determinations, with 10 degrees of freedom, of dissolved oxygen in air-saturated water (range 8,5 to 9 mg/l), carried out in four separate laboratories, gave within batch standard deviations between 0,03 and 0,05 mg of dissolved oxygen per litre.

## 9 Special cases

### 9.1 Presence of oxidizing substances

#### 9.1.1 Principle

Determination, by titration on a second test sample, of the content of oxidizing substances other than dissolved oxygen. Correction of the result obtained in clause 7.

#### 9.1.2 Procedure

9.1.2.1 Collect two test samples as specified in 6.3.

9.1.2.2 Carry out the determination of dissolved oxygen on the first test sample following the procedure specified in 6.4, 6.5 and 6.6.

9.1.2.3 Transfer quantitatively the second test sample to a conical flask of suitable size. Add 1,5 ml of the sulphuric acid solution (4.1) [or the corresponding volume of the phosphoric acid solution (see the note to 4.1)], then 2 ml of the alkaline reagent (4.3) and 1 ml of the manganese(II) sulphate solution (4.4). Leave for 5 min. Titrate with the sodium thiosulphate solution (4.6), using either the starch solution (4.7), added near the end of the titration, or another suitable indicator.

#### 9.1.3 Expression of results

The dissolved oxygen content, expressed in milligrams of oxygen per litre, is given by the formula

$$\frac{M_r V_2 c f_1}{4 V_1} - \frac{M_r V_4 c}{4 V_3}$$

where

$M_r$ ,  $V_1$ ,  $V_2$ ,  $c$  and  $f_1$  have the same meanings as in clause 7;

$V_3$  is the volume, in millilitres, of the flask containing the second test sample;

$V_4$  is the volume, in millilitres, of sodium thiosulphate solution (4.6) used to titrate the second test sample.

## 9.2 Presence of reducing substances

### 9.2.1 Principle

Oxidation of the reducing substances in the first and second test samples by addition of an excess of sodium hypochlorite solution.

Determination of the dissolved oxygen content of one of the test samples.

Determination of the excess of sodium hypochlorite in the other test sample.

### 9.2.2 Reagents

The reagents specified in clause 4, and

9.2.2.1 **Sodium hypochlorite**, solution containing approximately 4 g of free chlorine per litre, obtained by dilution of a commercial concentrated sodium hypochlorite solution, the concentration of which has been determined by iodometry.

### 9.2.3 Procedure

9.2.3.1 Collect two test samples as specified in 6.3.

9.2.3.2 Add to both test samples 1,00 ml (or, if necessary, a larger, accurately measured volume) of the sodium hypochlorite solution (9.2.2.1) (see footnote to 6.2). Stopper the flasks and mix.

Proceed on one test sample as specified in 6.4, 6.5 and 6.6 and on the other as specified in 9.1.2.3.

### 9.2.4 Expression of results

The dissolved oxygen content, expressed in milligrams of oxygen per litre, is given by the formula

$$\frac{M_r V_2 c f_2}{4 V_1} - \frac{M_r V_4 c}{4(V_3 - V_5)}$$

where

$M_r$ ,  $V_1$ ,  $V_2$  and  $c$  have the same meanings as in clause 7;

$V_3$  and  $V_4$  have the same meanings as in 9.1.3;

$V_5$  is the volume, in millilitres, of sodium hypochlorite solution added to the test sample (usually  $V_5 = 1,00$  ml);

$$f_2 = \frac{V_0}{V_0 - V_5 - V'}$$

where

$V'$  has the same meaning as in clause 7,

$V_0$  is the volume, in millilitres, of the flask containing the first test sample.

## 10 Test report

The test report shall contain the following information:

- a precise identification of the sample;
- the reference of the method used;
- the results, and the method of expression used;
- the ambient temperature and atmospheric pressure;
- any special details which may have been noted during the determination;
- details of any operations not specified in this International Standard or regarded as optional.