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Water quality — Examination and determination of colour

Qualité de l'eau — Examen et détermination de la couleur

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Foreword

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Water quality — Examination and determination of colour

0 Introduction

Pure water observed by transmitted light through a depth of several metres exhibits a light blue colour which may be modified in the presence of pollutants to produce an infinite variety of colours. Natural waters are mostly coloured yellowish brown by iron particles, clay particles, or by humic matter, and the observed colour may not be entirely due to completely soluble substances. For analytical purposes, however, it is the "true colour" of a sample which is of interest. The true colour is described as that due to dissolved substances (i.e. all materials that pass a 0,45 µm filter). Colour observed in the presence of undissolved suspended matter is described as "apparent colour". The inherent colour of water can be neglected in analytical practice.[1 to 5]

1 Scope and field of application

This International Standard specifies three methods for the determination of colour

section one specifies a method for the examination of colour by observing a water sample in a bottle. This gives only preliminary information, for example for use in field work. Only the apparent colour can be reported;

section two specifies a method for the determination of the colour of a water sample by visual means and may be applied to raw and potable water and also to industrial water of low colour. This method is subjective with respect to the operator;

section three specifies a method for the determination of the colour of a water sample by means of optical apparatus and is applicable to raw and potable water and to industrial water of low colour.

The methods may either be used independently or in combination.

Strongly coloured water samples must in some circumstances be diluted before examination or determination.

For interferences, see clause 14.

2 Reference

CIE Publication No. 17, *International lighting vocabulary.*

3 Definitions

For the purpose of this International Standard, the definitions given in CIE Publication No. 17, and the following, apply.

3.1 colour of water: Optical property of changing the spectral composition of transmitted visible light.

3.2 apparent colour of water: Colour due to dissolved substances and undissolved suspended matter; determined in the original water sample without filtration or centrifugation.

3.3 true colour of water: Colour due only to dissolved substances; determined after filtration of the water sample through a membrane filter of pore size 0,45 µm.

3.4 standard unit (of colour) mg/l Pt: The colour produced by a solution containing 1 mg of platinum per litre [in the form of hydrogen hexachloroplatinate(IV)], in the presence of 2 mg of cobalt(II) chloride hexahydrate per litre.

NOTE — The scale derived from this standard unit is sometimes called the "Hazen scale",[6] or the "Pt/Co scale".

Section one: Preliminary examination

4 Apparatus

Glass bottle, clean and clear, capacity 1 litre.

5 Sampling and samples

Maintain all glassware that will come into contact with the sample in scrupulously clean condition by washing with hydrochloric acid, or with surfactant cleaning solution. Finally rinse with distilled water and allow to drain.

Collect samples in glass bottles of at least 1 litre capacity [1] and carry out the colour test as soon as possible after collection. If storage is unavoidable, store the samples in the dark. In some cases it is necessary to prevent any contact between water samples and air. Also variations of temperature should be avoided.

6 Procedure

Put the unfiltered water sample into a bottle (clause 4) and examine the sample in diffused light against a white background for colour intensity and hue. If the sample contains suspended matter it should, if possible, be allowed to settle before examination.

7 Test report

The test report shall contain the following information:

a) a reference to this International Standard;

b) a reference to the method used;

c) the intensity of colour (colourless, pale, or dark);

d) the hue, for example yellowish brown;

e) if appropriate, the clarity of the sample (clear, cloudy, or opaque).

1) Plastics bottles may only be used if it can be demonstrated that they do not affect the colour of the sample.

Section two: Visual method

8 Principle

Determination of the intensity of the yellowish brown colour of a sample by visual comparison against a series of matching solutions or against a series of permanent glass standards.

Expression of the colour in terms of mg/l Pt units (3.4) representing the intensity of colour produced by the matching solutions (9.3).

9 Reagents

During the analysis, unless otherwise stated, use only reagents of recognized analytical grade.

9.1 Optically pure water.

Soak a membrane filter of pore size 0,1 µm (of the type used for bacteriological studies) for 1 h in 100 ml distilled or deionized water. Filter through it 250 ml distilled or deionized water and discard this water. Then twice filter a sufficient volume of distilled or deionized water and use this water subsequently for making all standard solutions and required dilutions.

9.2 Colour matching solution, stock, corresponding to 500 mg of Pt per litre.

Dissolve 1,245 ± 0,001 g potassium hexachloroplatinate(IV) (K_2PtCl_6) and 1,000 ± 0,001 g cobalt(II) chloride hexahydrate ($CoCl_2 \cdot 6H_2O$) in about 500 ml water (9.1). Add 100 ± 1 ml of optically pure hydrochloric acid (ϱ = 1,18 g/ml) and make up to the mark with water in a 1 litre volumetric flask.

Store the solution in a well-stoppered glass bottle in the dark at a temperature not exceeding 30 °C.

This solution will remain stable for at least 6 months.

9.3 Colour matching solutions.

Into a series of 250 ml volumetric flasks, introduce, by means of a pipette, 2,5; 5,0; 7,5; 10,0; 12,5; 15,0; 17,5; 20,0; 25,0; 30,0; and 35,0 ml of stock solution (9.2) and make up to the mark with water (9.1).

The solutions contain 5; 10; 15; 20; 25; 30; 35; 40; 50; 60; and 70 mg of Pt per litre.

Store the solutions in well-stoppered glass bottles in the dark at a temperature not exceeding 30 °C.

The solutions are stable for 1 month.

10 Apparatus

10.1 Comparators (commercially available).

The manufacturer's operating instructions shall be observed. Cells for the blank, or for the reference, shall be filled with optically pure water (9.1).

10.2 Permanent glass standards, covering a similar range of standard colours, in terms of mg/l Pt (3.4), as the matching solutions (9.3).

Their use is permissible provided that they are checked at intervals of 3 months against the matching solutions (9.3) and recalibrated if necessary. The calibration of the glass standards is only valid when they are used with the size of tube and the type of apparatus specified by the manufacturer.

The glass standards shall be recalibrated against the matching solutions if longer, non-standard tubes are used for comparison.

10.3 Standard observation tubes, for example Nessler tubes, tall form, 50 ml, optically clear glass with shadowless bottoms, or special observation tubes.

Larger non-standard tubes may be used.

10.4 Filtration apparatus, fitted with membrane filters of pore size 0,45 µm.

11 Sampling and samples

See clause 5.

12 Procedure

If the laboratory sample is turbid, filter it through a membrane filter of pore size 0,45 µm (10.4) before carrying out the determination of colour. (See the note.)

In the presence of clay, or other finely dispersed suspended matter, it may not be possible to obtain a bright filtrate, in which case only apparent colour is measured.

If the colour is ⩾70 mg/l Pt, dilute the sample with measured amounts of optically pure water (9.1) until the colour is within the range of the matching solutions or of the glass standards.

The pH of the sample should not be changed by the dilution water because the spectra of certain substances in water are pH dependent.

Fill a series of standard observation tubes (10.3) to the mark with the matching solutions (9.3). Fill another standard observation tube to the mark with the test portion.

Place the observation tubes on a white surface placed at such an angle that north light, or light from a white light cabinet, is reflected upwards through the columns of liquid.

Look vertically downwards through the columns of liquid. Match the intensity of the colour of the test portion with that of the nearest matching solution.

Alternatively, fill the tube of a comparator (10.1) to the mark with the sample and compare with the glass standards (10.2).

NOTE — If the membrane filter absorbs colouring substances, use another filter type, for example a glass fibre filter, and state this in the test report.

13 Expression of results

Report the value, in standard units of colour (3.4), as that of the nearest matching solution, or as that of the nearest matching glass standard, to the nearest 5 mg/l Pt in the range 0 up to, but not including, 40 mg/l Pt and to the nearest 10 mg/l Pt in the range 40 to 70 mg/l Pt.

If the sample has been diluted, report the colour, A_0, in terms of mg/l Pt, given by the equation

$$A_0 = \frac{V_1}{V_0} A_1$$

where

V_1 is the volume of the sample after dilution;

V_0 is the volume of the sample before dilution;

A_1 is the estimated colour of the diluted sample.

NOTES

1 If the colour of the sample does not match that of the standards, an approximate value may be reported with an appropriate note.

2 If matching is impossible, give a description of the colour of the sample.

3 The spectra of certain naturally dissolved substances in water are pH dependent. Therefore it is recommended that the pH value of samples be quoted together with the colour.

14 Interferences

Interferences will arise if the colour of the sample differs appreciably from the colour of the matching solutions or that of equivalent glass standards. In these cases a meaningful comparison may be impossible to obtain.

Finely divided suspended matter that interferes with the measurement of true colour shall be removed by filtration using a membrane filter of pore size 0,45 µm.

Problems may arise, however, if air should enter the sample during filtration and result in the formation of differently coloured oxidation species. For example iron or manganese compounds may be retained on the filter or may be transformed into differently coloured oxidation species.

15 Test report

The test report shall contain the following information:

a) a reference to this International Standard;

b) a reference to the method used;

c) precise identification of the sample;

d) the results expressed as specified in clause 13;

e) any deviation from the procedure specified or any circumstances that may have affected the results (for example filtration or dilution).

Section three: Spectrometric method

16 Principle

Characterization of the intensity of colour of a water sample by measuring the attenuation (absorption) of light. Different colours cause maximum absorption at different wavelengths of the incident radiation and the wavelength of maximum absorption must first be determined before measuring the degree of attenuation (absorbance) at that wavelength.

The absorption spectra of commonly occurring yellowish brown natural waters show absorption only at the short wavelength end of the visible spectrum. Whilst there is no well-defined wavelength of maximum absorption, wavelengths close to 400 nm are typical in the region where absorption occurs. Within this region the wavelength of the mercury line at 436 nm is particularly well suited for measurements of the colour of natural waters in view of the reproducibility of results.

Industrial waters may have colours that show strong absorption in other regions of the visible spectrum. Therefore more meaningful results will be obtained if measurement is made at the wavelength of the maximum absorption of the incident radiation by the sample.

Measurements of colour at other wavelengths are not comparable with measurements at 436 nm.

17 Apparatus

Either 17.1 or 17.2 may be used.

17.1 Spectrometer, with selectors for continuous variation (prism or grating type), capable of operating over the visible region of the spectrum, i.e. 350 to 780 nm, and preferably a double beam instrument of the recording type.

17.2 Spectrometer, with selectors for discontinuous variation (filter type), at a wavelength as near as possible to 436 nm and other wavelengths, if absorptions in different regions of the visible spectrum are to be measured, and of a bandwidth as small as possible.

18 Sampling and samples

See clause 5.

19 Procedure

If the laboratory sample is turbid, filter it through a membrane filter of pore size 0,45 µm. (See the note to clause 12.)

In the presence of clay, or other finely dispersed matter, it may not be possible to obtain a bright filtrate, in which case only apparent colour is measured.

If necessary, dilute the sample with measured amounts of optically pure water (9.1).

19.1 Determination of the wavelength of maximum absorption of industrial waters

The wavelength of maximum absorption is determined by inspection of the sample spectrum obtained by one of the following methods:

a) using a spectrometer (17.1) according to the manufacturer's instructions to measure absorption values over the range 350 to 780 nm and manually plotting absorbance against wavelength, in nanometres;

or more conveniently by

b) using a recording spectrometer (17.1) to obtain the spectrum directly;

c) using a spectrometer (17.2) to perform measurements with different light selectors.

19.2 Determination of colour

For natural waters, measure the absorbance of the sample in an appropriate size cell at a wavelength of 436 nm.

For industrial waters, measure the absorbance of the sample in an appropriate size cell at wavelengths of maximum absorption as determined in 19.1.

Cells for blank tests or for reference purposes shall be filled with optically pure water (9.1).

Note the thickness of the cell used.

20 Expression of results

20.1 Calculation

The spectral absorption coefficient, $a(\lambda)$, in reciprocal metres at wavelength λ, is given by the equation

$$a(\lambda) = \frac{A}{l} \times 1\,000$$

where

A is the absorbance of the sample at λ nm;

l is the thickness, in millimetres, of the cell used.

For natural waters, $\lambda = 436$ nm.

The spectra of certain naturally dissolved substances in water are pH dependent. Therefore it is recommended that the pH value of the sample be quoted together with the colour.

In the case of radiation which is not strictly monochromatic, the wavelength and the spectral bandwidth shall be stated (for example 436 nm, $\Delta\lambda = 21$ nm).

NOTES

1 If instrument calibration standards reveal any divergences from specified performance characteristics, the apparatus shall be serviced by a suitably qualified engineer.

2 Most spectrometers (17.1) are calibrated directly in terms of absorbance units. However, for instruments calibrated only in terms of transmittance (Φ_{tr}/Φ_0), the absorbance is given by the equation

$$A = \lg \frac{\Phi_0}{\Phi_{tr}}$$

where

Φ_0 is the incident flux;

Φ_{tr} is the transmitted flux.

3 It is possible to calibrate the spectrometer with the coloured matching solutions (9.2 and 9.3); using a standard graph or a correction factor, the results can be converted into mg/l Pt units.

20.2 Report the values in units of the spectral absorption coefficient to the nearest 0,001 m^{-1}. For statement in mg/l Pt, see the note to clause 13.

20.3 Statistical data

See the table.

Table — Standard deviation[1] (within batch) at wavelength 400 nm

Range	Standard deviation	Degrees of freedom
m^{-1}	m^{-1}	
0 to 0,75	0,018	53
>0,75 to 1,50	0,027	9

1) These figures are based on the difference between duplicate measurements and were obtained at the United Kingdom Water Research Centre, Medmenham.

21 Interferences

See clause 14, starting from the second paragraph.

22 Test report

The test report shall contain the following information:

a) a reference to this International Standard;

b) a reference to the method used;

c) precise identification of the sample;

d) the results expressed as specified in clause 20;

e) any deviation from the procedure specified or any circumstances that may have affected the results (for example filtration or dilution).