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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

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 7887 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 7887:1994), which has been technically revised.

Water quality — Examination and determination of colour

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 in accordance with this International Standard be carried out by suitably qualified staff.

1 Scope

This International Standard specifies four different methods, designated A to D, for the examination of colour.

The previously most employed method for assessment of water colour in water treatment plants, limnological surveys, etc. was based on the hexachloroplatinate scale (Reference [1]). Methods C and D are harmonized with this traditional procedure (References [2][3]).

Method A involves examination of apparent colour by visually 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.

Method B involves determination of the true colour of a water sample using optical apparatus and is applicable to raw and potable water and to industrial water of low colour. A subclause on interferences is included.

Method C involves determination of the true colour of a water sample using optical apparatus for comparison with hexachloroplatinate concentration at wavelength, $\lambda = 410$ nm. A subclause on interferences is included.

Method D involves determination of colour by visual comparison with hexachloroplatinate standard solutions and can be applied to raw and drinking water. A subclause on interferences is included.

Methods A and B are appropriate if the colour hue of the sample differs from the hue of the matching solution.

NOTE 1 Under certain circumstances, strongly coloured water samples require dilution before examination or determination. However, this can alter the physical-chemical conditions leading to a change in colour.

NOTE 2 An internal quality control procedure for all methods specified in this International Standard is given in Annex A. Precision data are given in Annex B.

When stating the result, the procedure used (methods A to D) is also recorded.

2 Normative references

The following referenced documents are indispensable for the application of this document. 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*

ISO 5667-3, *Water quality — Sampling — Part 3: Preservation and handling of water samples*

ISO 10523, *Water quality — Determination of pH*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
apparent colour of water
colour due to dissolved substances and undissolved suspended matter, determined in the original water sample without filtration or centrifugation

3.2
colour of water
optical property that causes the changing of the spectral composition of transmitted visible light

3.3
dissolved organic carbon
DOC
sum of organically bound carbon present in water originating from compounds passing through a membrane filter of 0,45 µm pore size, including cyanate and thiocyanate

[ISO 8245:1999,[6] 3.4]

NOTE DOC in natural waters often originates from natgural organic matter (NOM), a complex mixture of compounds formed as a result of the breakdown of animal and plant material in the environment. The composition of the mixture is strongly dependent on the environmental source. Spectroscopic methods are often used to characterize the dissolved organic matter in natural waters (Reference [4]). The ratio of UV absorbance and DOC concentration (specific UV-absorption, SUVA) has proved to be useful for optimization of water treatment processes.

3.4
specific colour
ratio between the true colour of a sample and its concentration of dissolved organic carbon

3.5
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

4 Method A: Visual examination

4.1 Sampling bottles

Colourless bottle, see ISO 5667-3.

Maintain all glassware that comes into contact with the sample in a scrupulously clean condition by washing with hydrochloric acid [$c(\text{HCl}) \approx 2 \text{ mol l}^{-1}$] or with surfactant cleaning solution which is recommended for laboratory use. Finally rinse with water for washing (5.4.2) and allow to drain.

4.2 Sampling and samples

Collect samples in bottles (4.1) and carry out the colour test as soon as possible. If storage is unavoidable, the samples can be stored for up to 5 days in the dark at 4 °C ± 2 °C. Prevent extensive aeration during storage, especially in cases where colour-changing redox reactions are likely to occur.

4.3 Procedure

Shake the sample to solubilize any matter that can dissolve.

Put the unfiltered sample into a bottle (4.1) and examine the sample in diffused light against a white background for colour intensity and hue. Allow any suspended matter that settles to do so before examination.

4.4 Qualitative description

State the intensity of the colour (nil, pale, light or dark) and the hue (e.g. yellow, yellowish brown).

EXAMPLE Apparent colour in accordance with ISO 7887, method A: pale, yellowish brown.

5 Method B: Determination of the true colour using optical instruments

5.1 General

The intensity of the colour of a water sample is characterized by its light absorption at the wavelength of maximum absorption and quantified by measuring the absorption coefficient with a filter photometer or spectrophotometer. Normally, most of the yellow-brown coloured natural waters, and the coloured waste water samples of discharges of domestic treatment plants can be measured at 436 nm. Waste water from industrial waste water treatment plants does not show sufficiently sharp and distinguished absorption maxima. Those waters shall be examined using the wavelengths specified in 5.2.

5.2 Principle

Characterization of the intensity of colour of a water sample is performed by measuring the attenuation (absorption) of light. Different colours cause maximum absorption at different wavelengths of the incident radiation. In accordance with Method B of this International Standard, the colour of the water is determined using a photometer or a spectrometer at a minimum of three different wavelengths, distributed over the range of the visible spectrum:

a) $\lambda(1) = 436$ nm;

b) $\lambda(2) = 525$ nm;

c) $\lambda(3) = 620$ nm.

Always use the wavelength $\lambda = 436$ nm (Hg 436 nm); wavelengths $\lambda(2)$ and $\lambda(3)$ can differ slightly from those specified above, depending on the type of optical filter employed. For a better characterization, measurements at additional wavelengths near the absorption maximum can be performed.

5.3 Interferences

Prior to measurement, the water sample is filtered (5.7) to avoid interferences by undissolved matter. This filtration can, however, lead to further interferences (e.g. due to oxidation reactions caused by contact with air or due to precipitations initiated by the filtration step). As an example, iron and manganese compounds can be retained on the filter or transferred to a coloured oxidation state. In some cases, particularly in the presence of colloidal solids, e.g. clay or other finely dispersed matter, it can prove impossible to obtain a clear filtrate. In this case, mention in the test report that colloidal solids are present.

NOTE Colours often depend on pH. Therefore, the pH of the water sample is regularly determined in parallel with optical measurements and these results are reported with the other findings.

5.4 Reagents

5.4.1 Optically pure water

Soak a membrane filter, of pore size 0,2 µm, in distilled or deionized water for approximately 1 h. Pass approximately 1 l of water, grade 1, as specified in ISO 3696 through the prepared filter, discarding the first 50 ml of filtrate.

NOTE If freshly distilled or deionized water has no measurable absorbance, it can be used.

5.4.2 Water for washing

Water, grade 3, as specified in ISO 3696.

5.5 Apparatus

5.5.1 Spectrophotometer (option 1), for continuous or discontinuous measurement, suitable for the visible range of the spectrum (approximately from 330 nm to 780 nm), preferably a scanning double beam instrument with bandwidth ≤10 nm.

5.5.2 Filter photometer (option 2), for discontinuous measurements, equipped with spectral line filters having a bandwidth which is as small as possible (about 20 nm), allowing measurements to include wavelengths 436 nm, 525 nm and 620 nm.

5.5.3 Membrane filter assembly, with filters of pore size 0,2 µm and 0,45 µm.

5.5.4 pH-meter.

5.6 Sampling and samples

See 4.2.

5.7 Procedure

Set up either the spectrophotometer (5.5.1) or filter photometer (5.5.2) and strictly observe the operating manual supplied by the manufacturer of the instrument. Prior to examination, filter the water sample through a membrane filter of pore size 0,45 µm (5.5.3). In parallel with each colour determination, measure the pH of the filtered sample in accordance with ISO 10523. In the case of strong colours, it can be necessary to use optical cells with suitable pathlengths down to 1 mm. The water sample can also be diluted with a measured volume of optically pure water (5.4.1), as appropriate, after filtration. The pH shall be measured before and after dilution.

Transfer the sample to the optical cell of the spectrophotometer or filter photometer and place optically pure water (5.4.1) in the reference cell.

If the spectral absorption coefficient, α, at the wavelength, λ, is less than 0,1 cm^{-1}, the optical pathlength of the cell should be 10 mm or more.

NOTE 1 A cell of optical pathlength down to 1 mm can be used to avoid diluting the sample.

Measure natural waters at 436 nm against optically pure water (5.4.1). Perform further measurements at 525 nm and 620 nm.

NOTE 2 In order to determine the absorption maximum, the entire absorption spectrum between 350 nm and 780 nm can be taken, using a scanning spectrophotometer (5.5.1).

5.8 Calculation

Calculate the spectral absorption coefficient, $\alpha(\lambda)$, absorbance per metre, using Equation (1):

$$\alpha(\lambda) = \frac{A}{d} f \tag{1}$$

where

A is the absorbance of the water sample at wavelength λ;

d is the optical pathlength, in millimetres, of the cell;

f is a factor to give the spectral absorption coefficient, in reciprocal metres ($f = 1\,000$).

The volume of water used for dilution should be taken into account when stating the result.

NOTE Most spectrophotometers are calibrated directly in terms of absorbance units. For instruments calibrated only in terms of transmittance, $T = \Phi_{\mathrm{tr}}/\Phi_0$, the absorbance, A, is given by Equation (2):

$$A = -\lg\left(\frac{\Phi_{\mathrm{tr}}}{\Phi_0}\right) \tag{2}$$

where

Φ_0 is the incident flux;

Φ_{tr} is the transmitted flux.

5.9 Expression of results

Apart from the absorption coefficient, $\alpha(\lambda)$, the wavelength of the incident light (e.g. 436 nm) shall be reported. For radiation which is not strictly monochromatic, the spectral half-intensity width ($\Delta\lambda$ bandwidth) shall also be reported. The spectral absorption coefficient shall be rounded to the nearest 0,1 m^{-1}.

EXAMPLE True colour in accordance with ISO 7887, method B.

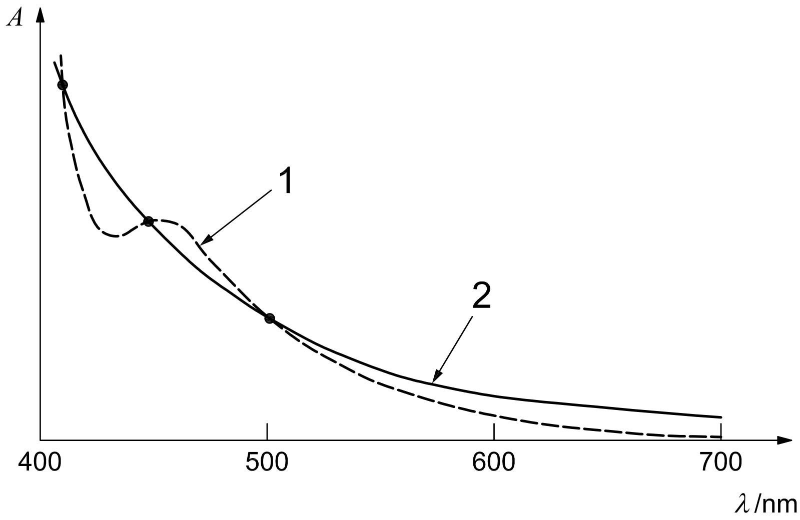
Spectral absorption coefficient, Hg $\lambda = 436$ nm:	5,2 m^{-1}
Spectral absorption coefficient, $\lambda = 525$ nm, $\Delta\lambda = 21$ nm:	1,8 m^{-1}
Spectral absorption coefficient, $\lambda = 620$ nm, $\Delta\lambda = 18$ nm:	2,3 m^{-1}
pH-value after filtration:	6,4

6 Method C: Determination of true colour using optical instruments for determination of absorbance at wavelength $\lambda = 410$ nm

6.1 Principle

The intensity of the yellowish brown colour of a sample is determined by measurement of the absorption coefficient at $\lambda = 410$ nm. Comparison with the specific absorption coefficient for a defined calibration solution of potassium hexachloroplatinate and cobalt chloride at the same wavelength gives the colour value in terms of mg l^{-1} Pt. This procedure can only be applied for true colour of optically clear samples (e.g. after filtration with pore size 0,45 µm).

NOTE The wavelength, $\lambda = 410$ nm, is chosen as the shortest at which the absorption spectra of a natural water sample visually denominated as 100 mg l^{-1} Pt in accordance with method D and the corresponding matching calibration solution of 100 mg l^{-1} Pt intersect (see Figure 1) (Reference [2]).



Key

1	matching solution
2	natural water
A	absorbance, relative scale
λ	wavelength

Figure 1 — Absorbtion spectra for a sample of natural water and a visually matching calibration solution both 100 mg l^{-1} Pt

6.2 Interferences

Finely dispersed suspended matter that interferes with the absorbance measurement shall be removed by filtration using a 0,45 µm membrane filter. Problems can arise, however, if air should enter the sample and result in formation of differently coloured oxidized species, e.g. iron or manganese can be retained on the filter or can be transformed into differently coloured oxidized species.

In some cases, especially in the presence of colloidal clay particles, it can prove impossible to obtain filtrates without turbidity. In such cases, a statement that the sample was turbid shall be reported together with the test result.

Clogging of the pores in a membrane filter reduces the pore size and can increase the retention of humus colloids, which decreases the colour values.

6.3 Reagents

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

6.3.1 **Stock colour calibration solution**, corresponding to 500 mg l^{-1} Pt.

Dissolve 1,245 g ± 0,005 g potassium hexachloroplatinate(IV) (K_2PtCl_6) and 1,000 g ± 0,005 g cobalt(II) chloride hexahydrate ($CoCl_2 \cdot 6H_2O$) in about 500 ml water (5.4.1). Add 100 ml ± 1 ml hydrochloric acid ($\rho = 1{,}18$ g ml^{-1}) and make up to the mark with water in a 1 000 ml one-mark volumetric flask.

Store the solution in darkness at 4 °C ± 2 °C in a well-stoppered dark brown glass bottle.

The solution is stable for at least 3 years.

CAUTION — Potassium hexachloroplatinate is a sensitizer and toxic compound. Use protection when handling the compound.

6.3.2 Colour calibration solution, for use, corresponding to 100 mg l^{-1} Pt.

Transfer by means of a volumetric pipette 20 ml of the stock solution (6.3.1) to a 100 ml one-mark volumetric flask and make up to the mark with water (5.4.1).

The solution is stable for at least 1 month when stored in a well-stoppered bottle in darkness at 4 °C ± 2 °C.

6.4 Apparatus

6.4.1 Spectrophotometer (option 1), for continuous or discontinuous measurement, suitable for measurement at $\lambda = 410$ nm with a bandwidth of ≤ 5 nm equipped with optical cells of glass or quartz with optical pathlength of 40 mm or 50 mm. Optical cells with 10 mm optical pathlength can be used for strongly coloured samples.

6.4.2 Filter photometer (option 2), for discontinuous measurements, equipped with spectral line filters having a bandwidth which is as small as possible (about 20 nm), allowing measurements to include the wavelength 410 nm.

6.4.3 Membrane filter assembly, with filters of pore size 0,2 µm and 0,45 µm.

6.4.4 pH-meter.

6.5 Sampling and samples

See 4.2.

6.6 Procedure

Set up either the spectrophotometer (6.4.1) or filter photometer (6.4.2) in accordance with the manufacturer's instructions.

Prior to examination, filter the water sample through a membrane filter of pore size 0,45 µm (6.4.3). Let the sample equilibrate to room temperature. In parallel with each colour determination, measure the pH of the filtered sample.

In the case of strong colours, the water sample can be diluted with a measured volume of optically pure water (5.4.1) to an intensity within the calibration range. Alternatively, after filtration, dilution can be omitted by use of an optical cell with suitable pathlength. Then measure the pH in accordance with ISO 10523.

Transfer the sample to the optical cell of the spectrophotometer or filter photometer and place optically pure water (5.4.1) in the reference cell.

6.7 Calculation

6.7.1 Determination of specific absorption for the calibration solution

Set up either the spectrophotometer (6.4.1) or filter photometer (6.4.2) in accordance with the manufacturer's instructions.

Measure A_{410} of the colour calibration solution (6.3.2) with optically pure water (5.4.1) in the reference cell.

Calculate the specific absorption coefficient, a, of the calibration solution given as A_{410} [mm^{-1} $(\text{mg l}^{-1}\ \text{Pt})^{-1}$] using Equation (3):