

INTERNATIONAL STANDARD

**ISO
7027**

Second edition
1990-04-15

Water quality — Determination of turbidity

Qualité de l'eau — Détermination de la turbidité



Reference number
ISO 7027 : 1990 (E)

Foreword

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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.

International Standard ISO 7027 was prepared by Technical Committee ISO/TC 147, *Water quality*.

This second edition cancels and replaces the first edition (ISO 7027 : 1984), of which it constitutes a minor revision.

Annex A of this International Standard is for information only.

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Printed in Switzerland

Introduction

Turbidity in liquids is caused by the presence of undissolved matter. In the case of undissolved, finely dispersed matter, the turbidity may be determined by measuring the attenuation of a radiant flux as it passes through the liquid or by measuring the intensity of diffused radiation. The diffusion of radiation is a property of liquids and can be used to measure turbidity. This International Standard describes both of these methods, together with methods which, although largely superseded since the development of optical turbidimeters, are still used for semiquantitative determinations, for example to obtain information in field work on surface and waste waters.

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Water quality — Determination of turbidity

Section 1: General

1.1 Scope

This International Standard specifies four methods for the determinations of turbidity of water.

Section 2 specifies semiquantitative methods, employed for example in field work:

- a) method using the transparency testing tube (suitable for pure and lightly polluted water);
- b) method using the transparency testing disk (especially suitable for surface water).

Section 3 specifies quantitative methods using optical turbidimeters:

- a) method by measuring diffused radiation, applicable to water of low turbidity (for example drinking water). Depending on the instrument design, it may also be used for waters of higher turbidity;
- b) method by measuring the attenuation of a radiant flux, more suitable for highly turbid waters (for example waste or polluted waters).

Measurements of turbidity can be affected by the presence of dissolved light-absorbing substances (substances imparting colour). Such effects can be minimized, however, by performing measurements at wavelengths greater than 800 nm. Only a blue colour, which may be found in certain polluted waters, slightly affects measurements of turbidity in this region of the spectrum. Air bubbles may also interfere with measurements but such interference may be minimized by careful handling of the samples.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International

Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3864 : 1984, *Safety colours and safety signs*.

ISO 6107-2 : 1989, *Water quality — Vocabulary — Part 2*.

CIE Publication No. 17 : 1987, *International Lighting Vocabulary*.

1.3 Definitions

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

turbidity: Reduction of transparency of a liquid caused by the presence of undissolved matter.

See also 3.1.

1.4 Sampling and samples

Maintain all glassware that comes into contact with the sample in a scrupulously clean condition. Wash with hydrochloric acid or surfactant cleaning solution.

Collect samples in glass bottles, fit stoppers, and carry out the determinations as soon as possible after collection. If storage is unavoidable, store the samples in a cool, dark room but not longer than 24 h. If the samples have been stored cool, allow to come to room temperature before measurement. Prevent contact between the sample and air and avoid unnecessary changes in the temperature of the sample.

Section 2: Semiquantitative methods

2.1 Method using the transparency testing tube

2.1.1 Apparatus

2.1.1.1 Transparency testing tube, consisting of a colourless glass tube 600 mm \pm 10 mm long and of internal diameter 25 mm \pm 1 mm, graduated in divisions of 10 mm.

2.1.1.2 Shield, close fitting, to protect the transparency testing tube from lateral light.

2.1.1.3 Print sample, placed under the tube (2.1.1.1) consisting of black print on a white background (height of characters 3,5 mm; line width 0,35 mm); or a **test mark** (for example a black cross on white paper) provided with the apparatus.

2.1.1.4 Constant light source: 3 W low voltage tungsten lamp, to illuminate the print sample or test mark (2.1.1.3).

2.1.2 Procedure

Thoroughly mix the sample and transfer it to the transparency testing tube (2.1.1.1). Steadily lower the sample level until the print sample or test mark (2.1.1.3) is clearly recognizable as viewed from above. Read the liquid height from the graduations on the tube.

2.1.3 Expression of results

Report the measured liquid height, to the nearest 10 mm, together with the apparatus used (name of the manufacturer).

2.2 Method using the transparency testing disk

NOTE — This method is intended primarily for testing bodies of water *in situ*.

2.2.1 Apparatus

The apparatus comprises a transparency testing disk made of cast bronze and coated with white (see ISO 3864) plastic, attached to a chain or rod.

NOTE — A typical design comprises a disk of diameter 200 mm with six holes, each of diameter 55 mm, on a circle of diameter 120 mm.

2.2.2 Procedure

Lower the disk, on its chain or rod, into the water until the disk is barely visible when viewed from above. Measure the length of immersed chain or rod. Repeat the test several times.

Ensure that no interference arises by reflection at the water surface.

2.2.3 Expression of results

Report the depth of immersion.

For values less than 1 m, report the result to the nearest 10 mm. For values greater than 1 m, report the result to the nearest 0,1 m.

Section 3: Quantitative methods using optical turbidimeters

3.1 General principles

A water sample coloured by dissolved substances is a homogeneous system that only attenuates radiation passing through the sample. A water sample containing undissolved substances attenuates the incident radiation and in addition the insoluble particles present diffuse the radiation unequally in all directions. The forward diffusion of radiation by the particles affects the attenuation so that the common spectral attenuation coefficient $\mu(\lambda)$ is the sum of the spectral diffusion coefficient $s(\lambda)$ and the spectral absorption coefficient $a(\lambda)$:

$$\mu(\lambda) = s(\lambda) + a(\lambda)$$

To obtain the spectral diffusion coefficient $s(\lambda)$ alone, the spectral absorption coefficient $a(\lambda)$ must be known. In order to determine the spectral absorption coefficient of the dissolved substance, the undissolved substances can, in some cases, be removed by filtration, but this may cause interferences. Therefore, it is necessary to report the results of the determination of turbidity in comparison to a calibration standard. The intensity of the diffused radiation depends upon the wavelength of the incident radiation, the measuring angle and on the shape, optical characteristics, and particle size distribution of the particles suspended in the water. In measurements of the attenuation of transmitted radiation, the measured value depends upon the aperture angle Ω_0 of the radiant efficiency arriving at the receiver. When measuring the diffused radiation, the measured values depend upon the angle θ and the aperture angle Ω_θ . The angle θ is that enclosed by the direction of the incident radiation and the direction of the measured diffused radiation (see figure 1).

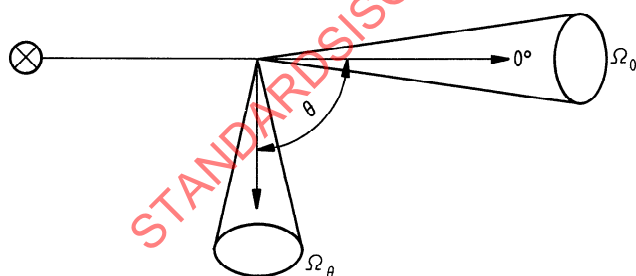


Figure 1

Application to the measurement of the concentration of undissolved substances would be possible only if the parameters identified above were known. In general, this information is not available, so the mass concentration of the suspended particles cannot be calculated from the value of turbidity.

NOTES

1 Instrument-to-instrument comparisons are only possible if apparatus is used in accordance with this International Standard and the same measuring principle is applied.

2 The Jackson candle turbidimeter was originally the standard instrument for turbidity measurements. In general, Jackson turbidity units (JTU) cannot be related to other turbidity units.

3.2 Reagents

All reagents shall be of recognized analytical grade.

All reagents shall be stored in hard glass bottles.

3.2.1 Water, for the preparation of standard matching solutions.

Soak a membrane filter of pore size 0,1 μm (of the type used for bacteriological studies) for 1 h in 100 ml of distilled water. Filter 250 ml of distilled water through it and discard the water. Then pass a 500 ml volume of distilled water twice through the membrane and reserve this water for the preparation of standard solutions.

3.2.2 Formazine ($\text{C}_2\text{H}_4\text{N}_2$), solution.

Formazine is not available commercially and it shall, therefore, be prepared as follows.

Dissolve 10,0 g of hexamethylenetetramine ($\text{C}_6\text{H}_{12}\text{N}_4$) in water (3.2.1) and dilute to 100 ml. (Solution A.)

Dissolve 1,0 g of hydrazine sulfate ($\text{N}_2\text{H}_6\text{SO}_4$) in water (3.2.1) and dilute to 100 ml. (Solution B.)

WARNING — Hydrazine sulfate is poisonous and may be carcinogenic.

Mix 5 ml of solution A with 5 ml of solution B. Leave for 24 h at $25^\circ\text{C} \pm 3^\circ\text{C}$. Then dilute the solution to 100 ml with the water (3.2.1).

The turbidity of this stock solution in formazine attenuation units (FAU) or formazine nephelometric units (FNU) is 400.

This solution is stable for about 4 weeks if stored at a temperature of $25^\circ\text{C} \pm 3^\circ\text{C}$ in the dark.

3.2.3 Formazine, standard matching solutions.

Dilute the stock solution (3.2.2) with water (3.2.1) using pipettes and volumetric flasks to obtain standard matching solutions of turbidities in the range of interest. These solutions are only stable for 1 week.

3.3 Method by measuring diffused radiation

3.3.1 Apparatus

Any apparatus may be used provided that it complies with the following requirements:

- the wavelength, λ , of the incident radiation¹⁾ shall be 860 nm;²⁾
- the spectral bandwidth, $\Delta\lambda$, of the incident radiation shall be less than or equal to 60 nm;
- there shall be no divergence from parallelism of the incident radiation and any convergence shall not exceed 1,5°;
- the measuring angle, θ , between the optical axis of the incident radiation and that of the diffused radiation shall be $90^\circ \pm 2,5^\circ$;
- the aperture angle, Ω_θ , should be between 20° and 30° in the water sample.

NOTE — According to recent investigations, it is preferable to have an angle of less than 20°.

3.3.2 Calibration

Calibrate the apparatus (3.3.1), operating in accordance with the manufacturer's instructions, using formazine standard matching solutions (3.2.3). Plot a graph from at least five points within each measuring range (for example for the range 0,1 FNU to 5,0 FNU, calibrate the apparatus at 0,5 FNU; 1,0 FNU; 2,0 FNU; 3,0 FNU and 4,0 FNU).

Repeat the calibration at frequent intervals.

NOTE — A turbidity corresponding to 0 FNU cannot be obtained because of molecular scattering of radiation.

3.3.3 Procedure

Fill a clean cell with the well-mixed sample and carry out the measurement immediately, operating in accordance with the manufacturer's instructions.

NOTE — In the case of apparatus for continuous measurement, air bubbles and settled substances will affect the result.

3.3.4 Expression of results

Report the result, in formazine nephelometric units

- if the turbidity is less than 1 FNU, to the nearest 0,01 FNU;
- if the turbidity is between 1 FNU and 10 FNU, to the nearest 0,1 FNU;
- if the turbidity is between 10 FNU and 100 FNU, to the nearest 1 FNU;
- if the turbidity is greater than or equal to 100 FNU, to the nearest 10 FNU.

3.3.5 Test report

The test report shall include the following information:

- a reference to this International Standard;
- the result, expressed in accordance with 3.3.4;
- details of any circumstances that might have influenced the result.

3.4 Method by measuring attenuated radiation

3.4.1 Apparatus

Any apparatus may be used provided that it complies with the following requirements:

- the wavelength, λ , of the incident radiation¹⁾ shall be 860 nm;²⁾
- the spectral bandwidth, $\Delta\lambda$, of the incident radiation shall be less than or equal to 60 nm;
- there shall be no divergence from parallelism of the incident radiation and any convergence shall not exceed 2,5°;
- the measuring angle (tolerance on deviation of the optical axis) shall be $0^\circ \pm 2,5^\circ$;
- the aperture angle, Ω_θ , should be between 10° and 20° in the water sample.

NOTE — According to recent investigations the angle should be less than 2,5°.

1) Tungsten lamps fitted with monochromators and filters, diodes and lasers may be used as sources of monochromatic radiation. However, some older apparatus fitted with tungsten lamps, but without monochromators or filters, is still in use (polychromatic sources) and, while the reproducibility of such apparatus may be less than that of apparatus providing monochromatic radiation, they can be used for the daily control and monitoring of turbidity at water works and treatment plants. Results cannot, however, be compared when using different apparatus.

2) Measurements at 860 nm show a lower intensity of diffused radiation in comparison with measurements at lower wavelengths. With some apparatus, the influence of stray light, or the noise level (background radiation), is such that it is impossible to measure very small degrees of turbidity, and it is preferable to operate at a wavelength of 550 nm with a bandwidth of 30 nm. In such cases, the water sample must be colourless. Results obtained at different wavelengths cannot be compared with those obtained at a wavelength of 860 nm.

3.4.2 Calibration

Calibrate the apparatus (3.3.1), operating in accordance with the manufacturer's instructions, using formazine standard matching solutions (3.2.3). Plot a graph from at least five points within each measuring range (for example for the range 0,1 FAU to 5,0 FAU, calibrate the apparatus at 0,5 FAU; 1,0 FAU; 2,0 FAU; 3,0 FAU and 4,0 FAU).

Repeat the calibration at frequent intervals.

NOTE — A turbidity corresponding to 0 FAU cannot be obtained because of molecular scattering of radiation.

3.4.3 Procedure

Fill a clean cell with the well-mixed sample and carry out the measurement immediately, operating in accordance with the manufacturer's instructions.

NOTE — In the case of apparatus for continuous measurement, air bubbles and settled substances will affect the result.

3.4.4 Expression of results

Report the result, in formazine attenuation units

- a) if the turbidity is less than 1 FAU, to the nearest 0,01 FAU;
- b) if the turbidity is between 1 FAU and 10 FAU, to the nearest 0,1 FAU;
- c) if the turbidity is between 10 FAU and 100 FAU, to the nearest 1 FAU;
- d) if the turbidity is greater than or equal to 100 FAU, to the nearest 10 FAU.

3.4.5 Test report

The test report shall include the following information:

- a) a reference to this International Standard;
- b) the result, expressed in accordance with 3.4.4;
- c) details of any circumstances that might have influenced the result.

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