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Fine bubble technology — Water treatment applications —

Part 1: Test method for evaluating ozone fine bubble water generating systems by the decolorization of methylene blue

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Technologie des fines bulles — Traitement de l'eau —

Partie 1: Méthode d'essai pour évaluer les diffuseurs à fines bulles d'ozone par la décoloration du bleu de méthylène

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Introduction

Ozone is used to improve water quality e.g. for purification and decomposition of hardly decomposable substances and decolorization. The conventional method often uses diffuser tubes. However, it has been found that with ozone fine bubbles, it is possible to use the strong oxidizing power of ozone more efficiently.

In recent years, the establishment of fine bubble generating technology has made ozone utilization efficiency higher than that of diffuser tube systems. Test results demonstrate that ozone fine bubble water generating systems are about 1,6 times more efficient than diffuser tube systems. With this efficiency increase, cost reduction has become possible.

Decolorization is mainly used for factory wastewater, regeneration and sewage water. It is also used on a regular basis for sewage treatment facilities, as advanced treatment technology in the dye-house effluent, etc.

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Fine bubble technology — Water treatment applications —

Part 1:
Test method for evaluating ozone fine bubble water generating systems by the decolorization of methylene blue

WARNING — Persons using this document should be familiar with normal laboratory practice. This document 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 determine the applicability of any other restrictions.

1 Scope

This document specifies a test method to assess the performance of ozone fine bubble water generating systems used for decolorizing water-soluble dye in e.g. wastewater and industrial water. This document does not address the impact of ozone on health and environment.

2 Normative references

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The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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ISO 10678, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Determination of photocatalytic activity of surfaces in an aqueous medium by degradation of methylene blue*

ISO 20480-1, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 1: Terminology*

ISO 20480-2:2018, *Fine bubble technology — General principles for usage and measurement of fine bubbles — Part 2: Categorization of the attributes of fine bubbles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20480-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
fine bubble water
water containing air fine bubbles

3.2
ozone fine bubble water
water containing ozone fine bubbles

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3.3
absorbance
natural logarithm of the ratio of the light amount before and after transmission of the test water-soluble dye with the photometric amount defined in ISO 80000-7:2019, 7-32.1

3.4
half-life of absorbance
time required for the change in absorbance to reach 50 % of the initial concentration

4 Decolorization test by ozone fine bubble water

4.1 Principle

A measured quantity of ozone is sent to a water-soluble dye tank through a fine bubble water generating system. The absorbance in the tank is optically measured to determine the half-life of absorbance. Absorbance is measured using e.g. a colorimeter, spectrophotometer or absorbance meter. It is desirable to use an inline type absorbance measuring instrument. Examples of inline measuring instruments are shown in Annex A.

4.2 Test environment conditions

The temperature of the test room should be 23 °C ± 3 °C and the relative humidity should be 50 % ± 10 %. In addition, it should be taken care not to mix fine particles in the test environment.

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4.3 Configuration of test equipment

The testing apparatus comprises a raw material gas supply unit, an ozone generator supply unit, a chemical reaction unit by ozone, and a discharged ozone treatment unit. The configuration of the test equipment is shown in Figure 1. The ozone reaction unit is indicated by a double line in Figure 1.

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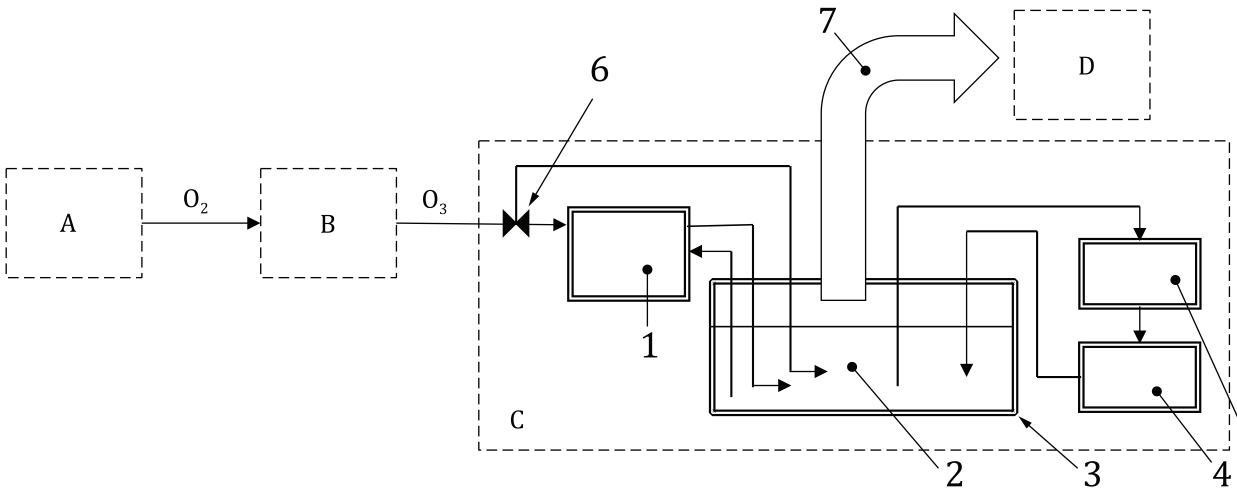

Key

1	fine bubble water generating system
2	fine bubble water with dissolved methylene blue
3	test tank
4	circulating pump
5	measurement instrument unit
6	valve
7	untreated O_3
A	raw material gas supply unit
B	ozone generator supply unit
C	chemical reaction unit by ozone
D	discharged ozone treatment unit

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Figure 1 — Configuration of test equipment

4.4 Raw material gas supply unit (A unit)

The raw material gas supply unit (A unit) is shown in Figure 1. Figure 1 shows a material gas supply unit when using an oxygen cylinder or an oxygen gas generator. The oxygen concentration of the material gas supply should be 90 % or more.

4.5 Ozone generator supply unit (B unit)

The conditions for supply of ozone to the ozone reaction unit shall be as follows:

a) The ozone flow rate shall be 0,5 l/min, the ozone yield shall be 3 g/h, it is important that the gas gauge pressure is set and maintained at a certain level of pressure. In addition, the numerical value of the gas gauge pressure shall be given in the test report, see Clause 7.

NOTE The conversion between ozone mass concentration and volume fraction is standardized by ISO 13964:1998, 7.2. The results are reported as micrograms per cubic meter at the chosen reference conditions, or as volume fraction. For ozone, a volume fraction of $1{,}0 \times 10^{-6}$ at 0 °C, 101,3 kPa (standard condition) is equivalent to 2 141 µg/m^3 and 1 995 µg/m^3 at 20 °C, 101, 3 kPa.

b) The ozone generator supply unit (B unit) is shown in Figure 1.

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4.6 Chemical reaction unit by ozone (C unit)

This C unit is composed of a fine bubble water generating system, a test tank, a measuring instrument and a circulating pump. The installation of fine bubble water generating system shall be structured so that the reference water-soluble dye in the test tank does not leak out of the system in case of immersion.

a) The fine bubble water generating system is as follows.

   1) The equipment has the function to discharge fine bubble water and to circulate it. A material that can withstand the oxidizing power of ozone shall be used.

   2) The operation conditions and data of fine bubble water generating system should be provided by the system supplier.

   3) Figure 1 shows the chemical reaction unit (C unit) using the fine bubble water generating system which includes the configuration of the reaction apparatus and dissolution apparatus of the ozone reaction section.

b) Test tank

   It is an aquarium that can be hermetically sealed so as not to leak ozone. It is made of a material that can withstand the oxidizing power of ozone. A colourless and transparent column is desirable to carry out the test while observing the change in colour. The column should have such an enough capacity that can reserve the ozone fine bubble water when it is generated. The reference test tank is made of glass with a capacity of 60 l or more, and the water depth at the time of test shall be 35 cm ± 1 cm.

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   The bottom area and the water surface area of the test tank should be equal.

   Validation or calibration of measuring equipment shall be as follows:

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   1) Ozone concentration meter, see ISO 1431-3;

   2) Photometric instrument, calibration and measurement confirmation of inline type measuring instrument using a standard solution;

   3) pH meter, adjusted with standard calibration solution.

c) Water

The water quality shall be determined in accordance with ISO 20480-2:2018, 4.2.

d) Methylene blue

Methylene blue powder specified in ISO 10678 shall be used.

NOTE The maximum absorption wavelength is 664 nm.

e) Methylene blue standard stock solution

Weigh 0,15 g of methylene blue powder and dissolve in 1 l of water.

f) Test coloured water

Prepare the test coloured water using 1 l of methylene blue stock solution, adjusted to 60 l. The pH of the test coloured water shall be $8 > pH > 5$. At the start of the test, it is recommended to set the water temperature to 20 °C ± 2 °C and neutral range of pH.

g) Circulating pump for absorbance measurement

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A pump with performance of about 7 l/min (flow rate 23 cm/s), that circulates water by sending the test water into the test tank to the measuring device is required.

h) Measuring unit. A measuring instrument for measuring the amount of visible light transmitted through a certain distance in water shall be as follows.

   1) The measurement wavelength shall be 664 nm.

   2) The measurement time is the time at which at least 5 cycles can be measured when a series of measurement cycles is performed until the methylene blue concentration becomes transparent from the initial high concentration. At least 100 points of light intensity measurement are performed during one cycle measurement, and the data are recorded together with the measurement time.

      It is necessary to be able to synchronize the measurement start signal with the fine bubble generation start signal including the artificial method.

   3) In order to minimize the dynamic behaviour of the fine bubble and the effect of decreasing the number concentration value, it is desirable to perform the sampling in as short a time as possible, or to measure by flow. Return the sampled sample to the test tank.

   4) The methylene blue concentration measurement of the test water shall be carried out considering one of the following measures because the fine bubble contained in the test water may affect the methylene blue concentration measurement.

      — Measure the absorbance of the test water and the absorbance of ozone fine bubble water without methylene blue and record each. The difference between these two values is subtracted from the output absorbance of the methylene blue concentration measuring instrument at the time of the test and corrected.

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      — The ozone fine bubble is introduced, and the transmittance in the test water tank is confirmed that the decolorization is advanced enough and the transmittance in the test water tank has become almost saturated. Then, it is used to estimate and correct the final value as a reference to the asymptotic change of the measured value by the measuring instrument. The uncertainty of the estimation is assessed, and the uncertainty of the correction is considered.

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4.7 Discharged ozone treatment unit (D unit)

See Figure 1.

4.8 Calibration procedure

Prepare five levels of known concentration of methylene blue solution in water wherein two levels shall be above and three levels shall be below the starting concentration in the measurement (see 4.9). For each level of concentration, take three replicates of absorbance measurement. Establish a calibration curve of absorbance to concentration by using least-square regression analysis.

4.9 Test procedure

The routine test procedure is as follows.

a) Install the test equipment, connect it, and confirm operation.

b) Perform calibration of the photometer.

c) Add 59 l of water to the test tank, add 1 l of methylene blue standard stock solution, and stir to obtain the coloured test water.

d) Measure the coloured test water with a photometer and measure the initial absorbance.

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