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Fine bubble technology — Evaluation method for determining gas content in fine bubble dispersions in water —

Part 1: Oxygen content

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Contents

Page

iTeh Standards
(https://standards.iteh.ai)
Document Preview
ISO 7383-1
https://standards.iteh.ai/catalog/standards/iso/a97e5989-6937-4a41-b994-8529415d50b0/iso-7383-1

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This document was prepared by Technical Committee ISO/TC 281, *Fine bubble technology*.

A list of all parts in the ISO 7383 series can be found on the ISO website.

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Document Preview
ISO 7383-1
https://standards.iteh.ai/catalog/standards/iso/a97c5989-6937-4a41-b994-8529415d50b0/iso-7383-1

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Introduction

Fine bubble dispersion in water has been used in various industries in recent years. Particularly in the fishery and food-processing industries, fine bubble technology is widely accepted as means for controlling dissolved oxygen level. For example, air fine bubbles are used to prevent oxygen depletion in the water of aquafarm and nitrogen fine bubbles are applied to reduce oxidization of fresh fish fillet.

The determination of the oxygen content in water is necessary to monitor the quality of object to be controlled by fine bubble dispersion in water. In the measurement of the oxygen content in fine bubble dispersion in water, however, attention should be paid to the possibility that the presence of fine bubbles themselves influences the measurement results.

In the case of air microbubble, air inside the bubbles is being dissolved during their slow floatation resulting in the increase in the oxygen content when oxygen is not oversaturated. In contrast, ultrafine bubbles (UFBs) have little influence on the oxygen content because the total amount of oxygen in UFBs is negligibly small compared to the intrinsic dissolved oxygen content in raw water. Furthermore, there is a possibility that the precipitation of visible bubbles on the surface of oxygen sensor, which is originated from dissolved gas, influences its measurement result.

Therefore, to evaluate the oxygen content of fine bubble dispersion in water, the state of bubbles in a sample water during the measurement is figured out.

This document is intended to specify the evaluation method of the oxygen content in fine bubble dispersion in water by three measurement methods: optical sensor, electrochemical probe and iodometric methods, which are widely accepted in industries. The standardized evaluation method for the oxygen content enables easy and solid comparison among fine bubble dispersion in various states.

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ISO 7383-1
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ISO 7383-1
https://standards.iteh.ai/catalog/standards/iso/a97c5989-6937-4a41-b994-8529415d50b0/iso-7383-1

Fine bubble technology — Evaluation method for determining gas content in fine bubble dispersions in water —

Part 1: Oxygen content

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 ensure compliance with any national regulatory conditions.

IMPORTANT — It is essential that tests conducted in accordance with this document be carried out by suitably trained staff.

1 Scope

This document specifies evaluation methods for the oxygen content in fine bubble dispersion in water.

Three test methods which are adopted include the optical sensor, the electrochemical probe and the iodometric method. The first two methods have an advantage in availability of in situ and real-time measurement, and high accessibility to commercially available instruments. The last one, composed of a well-established chemical analysis procedure, is advantageous in the situation where the instruments to be used in the first two methods are unavailable.

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Document Preview
ISO 7383-1

The detection limits of the electrochemical and optical sensor methods are stated in the instruction manuals of the instruments, in most cases 0,1 mg/l or 0,2 mg/l. The upper limit depends on the specification of the instrument used. Most instruments allow measurement of a supersaturated sample.

Measurement range of the iodometric method is between 0,2 mg/l and 20 mg/l.

NOTE Chemical analysis methods other than the iodometric method can be applied[1] as an alternative.

2 Normative references

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.

ISO 5813:1983, *Water quality — Determination of dissolved oxygen — Iodometric method*

ISO 5814:2012, *Water quality — Determination of dissolved oxygen — Electrochemical probe method*

ISO 17289:2014, *Water quality — Determination of dissolved oxygen — Optical sensor method*

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

ISO/TR 23015, *Fine bubble technology — Measurement technique matrix for the characterization of fine bubbles*

3 Terms and definitions

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

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

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

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

3.1
UFB dispersion
UFBD
liquid which contains ultrafine bubbles

[SOURCE: ISO 21255:2018, 3.2[2]]

4 Interferences

4.1 Iodometric method

Readily oxidizable organic substances such as tannins, humic acid and lignins, interfere. Oxidizable sulfur compounds such as sulfides and thiourea also interfere.

To avoid such interferences, it is preferable to use the electrochemical probe, or the optical sensor method described in ISO 5714 or ISO 17289 respectively.

In the presence of suspended matter capable of fixing or consuming iodine, or if in doubt about the presence of such matter, the modified procedure described in ISO 5813:1983, Annex, shall be used.

Preferably, however, determine the oxygen content with the electrochemical probe or the optical sensor method described in ISO 5714 or ISO 17289 respectively.

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ISO 7383-1

4.2 Electrochemical probe method

Gases and vapours such as chlorine, hydrogen sulfide, amines, ammonia, bromine and iodine which diffuse through the membrane can interfere.

Solvents, oils, sulfides, carbonates and biofilms can also interfere with the measured current by causing obstruction and deterioration of the membrane or corrosion of the electrodes.

If in doubt about such interferences, it is preferable to use the optical sensor method described in ISO 17289.

5 Implication of measurement result

In the measurement of MB dispersion in water, the oxygen content should be determined after the bubbles are completely dissolved in the water sample. When MBs remain in water, the measured data indicate those in the process of dissolving of MBs.

In the measurement of UFB dispersion in water, the implication of measurement results differs depending on whether UFBs are present or not during the measurement. When UFBs are present, the data indicate the dissolved oxygen in coexistence with UFBs. When they are not present, the data indicate the total oxygen content of dissolved oxygen and UFBs.

The presence of UFBs shall be verified with one of the characterization techniques described in ISO/TR 23015.

6 Requirement

6.1 General

During sampling, transportation and storage of the water sample to be measured, oxygen uptake and oxygen stripping shall be minimized.

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6.2 Correction for the salinity of sample water

If the optical sensor or electrochemical probe methods are used for saline water such as sea or estuarine waters, the salinity of sample water shall be input into the instrument. The salinity is estimated by the procedure described in ISO 17289:2014, Annex A for the optical sensor method or ISO 5814:2012, Annex A for the electrochemical probe method.

If the instrument does not have compensatory function for salinity, compensating procedure is described in ISO 5814:2012, Annex A.

7 Apparatus

7.1 Optical sensor method

The specification of the measuring instrument is described in ISO 17289:2014, Clause 6.

If extremely high oxygen level is expected, an optical sensor of sufficiently wide measuring range should be chosen.

If an adequate sensor is not available, the sample can be diluted before measurement according to the procedure described in ISO 20298-1.[3] Attention should be paid to a possibility that the oxygen content is varied during dilution.

7.2 Electrochemical probe method

The specification of the measuring instrument is described in ISO 5814:2012, Clause 6.

NOTE Usually, a temperature sensor and a barometer are part of the instrument used for the electrochemical probe and optical sensor methods.

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7.3 Iodometric method

Ordinary laboratory equipment and narrow-mouthed glass flasks specified in ISO 5813:1983, Clause 5 are required.

ISO 7383-1
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8 Procedure

8.1 General

To evaluate the increase or decrease of the oxygen content by the generation of fine bubbles, the dissolved oxygen level of blank water shall be determined with the methods specified in 8.2 to 8.4, and the value shall be deducted from the oxygen content measurements of fine bubble dispersions.

The difference among the measurement results by the three methods, iodometric, electrochemical probe and the optical sensor methods, can be found in Annex A.

The influence of bubble attachment to sensor surface on the measurements of the oxygen content by the optical sensor and electrochemical probe methods can be found in Annex B.

8.2 Optical sensor method

8.2.1 General

The procedure is described in ISO 17289:2014, Clause 7. Normally, the measurement shall be carried out directly on-site in the water body to be analysed. If direct measuring is not possible, the measurement using a gastight connected flow-through device[4] is an alternative. Measuring immediately after discrete sampling is another alternative.

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Any discrete sampling procedure will result in a higher measurement uncertainty.

8.2.2 Sampling, measuring technique and precautions to be taken

Sampling procedure shall be in accordance with ISO 17289:2014, 7.1.1. Measuring techniques and precautions to be taken shall be in accordance with ISO 17289:2014, 7.2.

In the measurement of MB or UFB dispersion in water during the operation of bubble generator, the formation of visible bubbles on the surface of sensor shall be minimized.

NOTE To reduce the adverse effect of visible bubbles, the following can show practical effect:

— shaking off bubbles by tapping sensor body routinely;

— making sensor surface upward or inclined from the perpendicular.

In the discrete sampling of MB or UFBD using a sample vessel, confirm the disappearance of MBs by dissolution or flotation ahead of the sampling by the naked eye. The formation of visible bubbles on the surface of sensor shall also be minimized.

8.2.3 Calibration

Calibration shall be in accordance with ISO 17289:2014, 7.3.

8.2.4 Determination

Determination shall be in accordance with ISO 17289:2014, 7.4.

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8.3 Electrochemical probe method

8.3.1 General

The procedure is described in ISO 5814:2012, Clause 7. The measurement shall be carried out directly on-site in the water body to be analysed. If direct measuring is not possible, the measurement using gastight connected flow-through device[4] is an alternative. Measuring immediately after discrete sampling is another alternative.

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Any discrete sampling procedure will result in a higher measurement uncertainty.

8.3.2 Sampling, measuring technique and precautions to be taken

Sampling procedure shall be in accordance with ISO 5814:2012, 7.1.1. Measuring techniques and precautions to be taken shall be in accordance with ISO 5814:2012, 7.2.

Additional measuring techniques and precautions to be taken are the same as those for the optical sensor method described in 8.2.2.

8.3.3 Calibration

Calibration shall be in accordance with ISO 5814:2012, 7.3.

8.3.4 Determination

Determination shall be in accordance with ISO 5814:2012, 7.4.

8.4 Iodometric method

The procedure is described in ISO 5813:1983, Clause 6.

Confirm the disappearance of micro bubbles in the flask after sampling.

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