BRITISH STANDARD

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12255-15:2003

Wastewater treatment plants —

Part 15: Measurement of the oxygen transfer in clean water in aeration tanks of activated sludge plants

The European Standard EN 12255-15:2003 has the status of a British Standard

ICS 13.060.30

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National foreword

This British Standard is the official English language version of EN 12255-15:2003.

The UK participation in its preparation was entrusted to Technical Committee B/505, Waste water engineering, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

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This British Standard, was published under the authority of the Standards Policy and Strategy Committee on 17 December 2003

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EUROPEAN STANDARD
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EN 12255-15

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English version

Wastewater treatment plants - Part 15: Measurement of the oxygen transfer in clean water in aeration tanks of activated sludge plants

Stations d'épuration - Partie 15: Mesure de performances des aérateurs

Kläranlagen - Teil 15: Messung der Sauerstoffzufuhr in Reinwasser in Belüftungsbecken von Belebungsanlagen

This European Standard was approved by CEN on 3 November 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Foreword

This document (EN 12255-15:2003) has been prepared by Technical Committee CEN/TC 165 “Waste water engineering”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

It is the fifteenth Part prepared by the Working Groups CEN/TC 165/WG 42 and 43 relating to the general requirements and processes for treatment plants for a total number of inhabitants and population equivalents (PT) over 50. EN 12255 with the generic title "Wastewater treatment plants" consists of the following Parts:

¾ *Part 1: General construction principles*

¾ *Part 3: Preliminary treatment*

¾ *Part 4: Primary settlement*

¾ *Part 5: Lagooning processes*

¾ *Part 6: Activated sludge process*

¾ *Part 7: Biological fixed-film reactors*

¾ *Part 8: Sludge treatment and storage*

¾ *Part 9: Odour control and ventilation*

¾ *Part 10: Safety principles*

¾ *Part 11: General data required*

¾ *Part 12: Control and automation*

¾ *Part 13: Chemical treatment — Treatment of wastewater by precipitation/flocculation*

¾ *Part 14: Disinfection*

¾ *Part 15: Measurement of the oxygen transfer in clean water in aeration tanks of activated sludge plants*

¾ *Part 16: Physical (mechanical) filtration*

NOTE For requirements on pumping installations at wastewater treatment plants, provided initially as *Part 2: Pumping installations for wastewater treatment plants*, see EN 752-6 *Drain and sewer systems outside buildings — Part 6: Pumping installations*.

The parts EN 12255-1, EN 12255-3 to EN 12255-8 and EN 12255-10 and EN 12255-11 were implemented together as a European package (Resolution BT 152/1998).

Annex A is normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

This European Standard specifies the non-steady state measurement of the oxygen transfer rate and the oxygen transfer efficiency of aeration systems in activated sludge aeration tanks (see EN 12255-6) when filled with clean water.

NOTE 1 This is known as the clean water test.

NOTE 2 Since the method is based on completely mixed tanks or tanks with evenly distributed aerators or diffusers test results from certain aeration installations can be incorrect.

NOTE 3 Under process conditions with mixed liquor the oxygen transfer rate and the oxygen transfer efficiency can be different from the clean water test results. This is expressed by the -factor.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1085, *Wastewater treatment — Vocabulary.*

EN 25814, *Water quality — Determination of dissolved oxygen — Electrotechnical probe method (ISO 5814:1990).*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1085 and the following apply.

3.1
standard oxygen transfer rate (SOTR, kg/h)

mass of oxygen transferred per hour at standard conditions (water temperature *T* = 20 °C, barometric pressure p = 1 013 hPa, zero dissolved oxygen concentration), to an aeration tank filled with clean water (Volume *V*, m³) equipped with an aeration device or system and operated at a specified aeration setting. It is obtained as:

$$SOTR = V \quad k_L a_{20} \quad C_{S,20} / 1000 \qquad (1)$$

3.2
standard aeration efficiency (SAE, kg/kWh)

ratio of standard oxygen transfer rate and total wire power uptake (*P*, kW) measured during the test

3.3
specific standard oxygen transfer efficiency (SSOTE, %/m)

percent oxygen absorbed per metre diffuser submergence (h_D, m). SSOTE may also be expressed in g/(m³·m)[1]

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[1] The volume expressed in m^3 is applicable to standard conditions (dry air, zero humidity, p=1013 hPa, T=0°C), see also 3.9.

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$$SSOTE = 100 \quad SOTR/\left(h_{\mathrm{D}} \quad Q_{\mathrm{A}} \quad 0{,}299\right)\left[\%/\mathrm{m}\right] \tag{2}$$

or

$$SSOTE = 1000 \quad SOTR/\left(Q_{A} \quad h_{D}\right)\left[g/(m^{3} \times m)\right] \tag{3}$$

3.4
oxygen transfer coefficient ($k_{\mathrm{L}}a_{\mathrm{T}}$, h^{-1})

determined by evaluation of an oxygen transfer test in clean water at a certain aeration setting and at a certain temperature. It is converted to the standard temperature of T = 20 °C as follows:

$$k_{\mathrm{L}}a_{20} = k_{\mathrm{L}}a_{\mathrm{T}} \quad 1{,}024^{(20\text{-}\mathrm{T})} \tag{4}$$

3.5
standard oxygen saturation value ($C_{\mathrm{S,St,T}}$, mg/l)

as listed in EN 25814 for p_{St} = 1 013 hPa, e.g.: $C_{\mathrm{S,St,20}}$ = 9,09 mg/l

3.6
test oxygen saturation value ($C_{\mathrm{S,p^*,T}}$, mg/l)

oxygen saturation value of an oxygen transfer test in clean water at a specific water temperature (T, °C) and a specific barometric pressure (p*, hPa). The test oxygen saturation value is converted to standard conditions as follows:

$$C_{\mathrm{S,20}} = C_{\mathrm{S,p^*,T}} \quad (C_{\mathrm{S,St,20}} / C_{\mathrm{S,St,T}}) \quad (p_{\mathrm{St}} / p^{*}) \tag{5}$$

3.7
mid-depth oxygen saturation value ($C_{\mathrm{S,md,20}}$, mg/l)

for diffused air aeration the mid-depth oxygen saturation value for standard conditions is calculated as follows (10,35 m of water is equivalent to 1 013 hPa):

$$C_{\mathrm{S,md,20}} = C_{\mathrm{S,St,20}} \quad [1 + \left(h_{\mathrm{D}} / (2 \quad 10{,}35)\right)] \tag{6}$$

3.8
diffuser submergence (h_{D}, m)

depth below the water level of air release from the diffuser without aeration operating

3.9
normal air flow rate (Q_{A}, m³/h)

air flow rate delivered to the aeration tank, corrected for standard conditions (dry air, zero humidity, p = 1 013 hPa, T = 0 °C)

3.10
aeration setting

for diffused air aeration: a specified air flow rate at a specified diffuser depth with or without additional mixing; for surface aerators: a specified freeboard or a specified immersion depth at a specified rotary speed and with or without baffles and/or additional mixing

4 Symbols and abbreviations

h_{D}	diffuser submergence, in metre (m)
C_0	oxygen concentration at t = 0, in milligramme per litre (mg/l)

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C_i	initial concentration of dissolved oxygen in the tank without sodium sulphite, in milligramme per litre (mg/l)
$C_{S,20}$	test oxygen saturation value at standard conditions, in milligramme per litre (mg/l)
$C_{S,md,20}$	mid-depth oxygen saturation value, in milligramme per litre (mg/l)
$C_{S,p^*,T}$	test oxygen saturation value, in milligramme per litre (mg/l)
$C_{S,p°,T°}$	oxygen saturation value after a prolonged aeration period determined by Winkler titration (see EN 25813), in milligramme per litre (mg/l)
$C_{S,St,T}$	standard oxygen saturation value, in milligramme per litre (mg/l)
$C_{S,St,T°}$	standard oxygen saturation value at the temperature at which the saturation value has been determined by Winkler titration, in milligramme per litre (mg/l)
C_t	oxygen concentration at time t, in milligramme per litre (mg/l)
$k_L a_{20}$	oxygen transfer coefficient at T = 20 °C, in 1/h
$k_L a_T$	oxygen transfer coefficient at test temperature, in 1/h
M_{So}	mass of sodium sulphite needed for one test, in kilogramme
$p°$	barometric pressure during sampling for Winkler titration, in hectopascal (hPa)
p^*	barometric pressure during a test, in hectopascal (hPa)
p_{St}	barometric standard pressure (1 013 hPa), in hectopascal (hPa)
Q_A	normal air flow rate, in cubic metre per hour (m^3/h)[2]
t_M	mixing period at oxygen concentration C = 0, in minutes (min)
V	tank volume, in cubic metre[3] (m^3)

5 Principle and procedures

After decreasing (absorption test) or increasing (de-sorption test) the dissolved oxygen concentration of an aeration tank at constant mixing and a certain aeration setting the increasing or decreasing dissolved oxygen concentration is monitored. This is described by the following equation:

$$C_t = C_{S,p^*,T} \quad (C_{S,p^*,T} \quad C_0)\ \exp(\quad k_L a_T \quad t) \tag{7}$$

By a non-linear regression method equation (7) is fitted to the measured values of C_t. The values for C_0, $C_{S,p^*,T}$ and $k_L a_T$ are obtained. The residues (C_t (measured) - C_t (calculated)) plotted versus time shall be randomly distributed. If they follow a curve a new evaluation shall be performed at which one or more values of C_t from the beginning and/or end of the curve are to be neglected. Any computer program for non-linear parameter

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[2] The volume expressed in cubic metre is applicable to standard conditions (dry air, zero humidity, p=1013 hPa, T=0°C), see also 3.9.

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estimation may be used, e.g. Stenstrom et al. [1981]. The disks provided by ASCE [1992], by ATV [1996] or by FUL [1995] may be used as well.

The value of k_La_T is not affected by the calibration of the DO probes. The exact determination of $C_{S,p^*,T}$ requires accurately calibrated DO probes or Winkler titration, see EN 25813 and EN 25814.

Experienced Institutions may apply linear estimation (log deficit method) of k_La_T using a measured oxygen saturation value $C_{S,p^\circ,T}$, see annex A.

The oxygen transfer absorption test is the most common test method by which the dissolved oxygen concentration of the aeration tank is at first decreased by addition of sodium sulphite or by injection of nitrogen gas and then aerated close to oxygen saturation. From the increasing dissolved oxygen concentration monitored during the aeration period the oxygen transfer coefficient and the oxygen saturation value are determined.

Clean water oxygen transfer de-sorption testing is a newer test method. By injection of pure oxygen gas the dissolved oxygen concentration of the aeration tank at first is raised beyond the (air) oxygen saturation concentration and then aerated close to air oxygen saturation. From the decreasing dissolved oxygen concentration monitored during the aeration period the oxygen transfer coefficient and the oxygen saturation value are to be determined.

6 Aeration tanks, test-water, equipment and chemicals

6.1 Aeration tanks and aeration installations

The tanks may be square, circular, rectangular or a closed loop (e.g. oxidation ditch) in plan.

The aeration systems mainly used today can be categorised as diffused air systems (e.g. porous diffusers, ejectors), vertical shaft surface aerators (e.g. cone aerators) and horizontal axis surface aerators.

Diffused air aeration can be installed in any tank and propellers may be installed to create a horizontal flow in circular tanks and in closed loop tanks.

Vertical shaft surface aerators may be installed in square, circular, rectangular and closed loop tanks. Horizontal axis surface aerators today are only installed in closed loop tanks. In closed loop tanks with surface aerators propellers may be installed to maintain a sufficient flow velocity. Since for surface aerators the depth of immersion is important, during filling of the tank a mark for zero immersion should be made when half of the (running) aerators touch the water level.

6.2 Measuring Equipment

6.2.1 Dissolved oxygen probes (DO probes)

At least three DO probes shall be installed in the aeration tank. In large aeration tanks ($V > 3\,000$ m³) and in tanks with tapered aeration it is advisable to install 6 or more DO probes.

Calibration of the DO probes shall be carried out in accordance with EN 25814.

The response period of the DO probes shall be less than 1/20 of the response period of the aeration tank, hence the probe k_La_T shall be higher than 20 times the aeration tank k_La_T.

At installations with $k_La_T > 20$ h^{-1} due to a required probe $k_La_T > 400$ h^{-1}, k_La_T may be incorrect.

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6.2.2 Recording of the dissolved oxygen concentration

At least one DO probe shall be connected to a continuously recording display device. The signals of the remaining probes then shall be manually recorded at appropriate time intervals.

It is preferable to use a data logger for all DO probes. Also in this case either on a screen or by a strip chart recorder the course of the oxygen concentration of at least one DO probe shall be shown during the test.

The frequency of recording C_t shall be as high as possible. At least 30 pairs of C_t/t shall be used for the determination of $k_L a_T$.

6.2.3 Temperature measurement

The temperature of the water in the aeration tank shall be measured with an accuracy of ± 0,1 °C at the beginning and the end of each test.

6.2.4 Power measurement

The total wire power of the aeration equipment (motors of blowers or surface aerators including frequency controllers) and the operating mixing equipment shall be measured either with temporary or installed kWh-meters or kW-instruments with an accuracy of ± 3 %.

6.2.5 Air flow measurement

If at diffused air installations the oxygen transfer efficiency is to be determined, the normal air flow rate shall be measured by appropriate equipment with an accuracy of ± 5 %.

If at diffused air installations only a fraction of the air delivered by the blower is used for aeration of the tank to be tested, the air flow rate to the tank and the total air flow rate of the blower shall be measured by appropriate equipment with an accuracy of ± 5 %.

6.3 Chemicals

6.3.1 Sodium sulphite

Either technical-grade or photo-grade sodium sulphite (Na_2SO_3) shall be used for de-oxygenation. To remove 1 kg of dissolved oxygen 8 kg of Na_2SO_3 are required. The dissolved solids are increased by 1,13 kg per kg of Na_2SO_3.

6.3.2 Cobalt catalyst

Either reagent or technical-grade cobalt chloride ($CoCl_2$ 6 H_2O) or cobalt sulphate ($CoSO_4$ 7 H_2O) shall be used to catalyse the de-oxygenation reaction. The amount of cobalt to be added may be determined on site. A concentration of 0,5 mg/l Co in any case is sufficient and shall not be exceeded.

6.3.3 Nitrogen and pure oxygen gas

The gas is delivered in liquid form or in gas bottles tied up in bundles. Appropriate pressure reducers are required. The measurement of the gas flow is useful at de-sorption tests in order to maintain the appropriate oxygen-air fraction. During handling of oxygen gas, strict safety rules shall be observed to avoid the risk of explosion.

6.4 Test-water

The water to be used for testing should be equivalent to drinking water quality with the exception of pollutants which do not influence oxygen transfer e.g. nitrate and nitrite and pathogenic organisms.

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Water with an initial concentration of total dissolved solids of more than 500 mg/l should not be used for absorption testing since by addition of sodium sulphite the concentration is increased.

Organic compounds in the water lead to complexing of the cobalt catalyst; they can also reduce the oxygen transfer. Therefore biologically treated final effluent or water coloured by algae should not be used as test-water.

Prior to testing, a representative sample of water shall be analysed for total dissolved solids. When drinking water is not used other parameters of concern should be considered e.g. iron, manganese, alkalinity, pH, dissolved organic carbon and surfactants.

When water which may contain unknown organic substances shall be used for testing, oxygen transfer tests in a pilot tank (similar depth to the full scale tank and with a similar $k_{\mathrm{L}}a_{20}$) with drinking water and test-water shall be performed. The test-water may be used if the deviation of $k_{\mathrm{L}}a_{20}$ between test water and drinking water is within a limit of ± 5 %.

The use of other than drinking water shall be agreed upon by the client and the contractor or manufacturer.

7 Procedure

7.1 Planning of testing

If absorption tests with de-oxygenation by sodium sulphite are planned, the number of tests to be performed with the same test-water shall be calculated. Repetitive tests may be conducted in the same water, provided that the total dissolved solids concentration does not exceed 2 000 mg/l which approximates to an electrical conductivity of 3 000 µS/cm.

There are no limitations if de-oxygenation is achieved by nitrogen gas injection or by de-sorption tests after pure oxygen injection.

An initial test should be considered as a trial run for the oxygen transfer determination as there may be an inadequate distribution of sodium sulphite, inappropriate placement of the DO probes or other anomalies. The test data may be used if no abnormalities are observed.

In case of compliance testing at each aeration setting a minimum of 2 tests should be performed. With the same filling of water using sodium sulphite for de-oxygenation, the testing of two aeration settings is possible, considering the initial test as invalid.

Due to the increasing concentration of dissolved solids the quality of water changes from test to test. If different aeration settings have to be tested the tests should be symmetrically distributed.

7.2 Advance preparation and responsibilities

In order that this standard is appropriately applied to on-site testing, the client or his engineer and the contractor or manufacturer shall agree in advance to the test conditions and procedure. The items upon which agreement shall be reached include:

¾ which aeration tank or which part of an aeration tank shall be used;

¾ what measures are taken to ensure that the water level in the tank stays constant during a test and, if a part of a tank is used, how an exchange of water between the part for testing and the rest of the tank is avoided;

¾ specification of the source and quality of the water to be used for testing if drinking water is not used;

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¾ test method (absorption test: de-oxygenation by sodium sulphite or nitrogen gas, de-sorption test after raising the dissolved oxygen concentration by injection of oxygen gas);

¾ procedure for the addition of sodium sulphite (liquid, dry, number of points of addition);

¾ method of power measurement and if required the method of air flow measurement;

¾ number and location of DO probes; the results of preliminary testing may necessitate relocation of the probes;

¾ aeration settings (air flow rate, number of surface aerators, immersion depth of surface aerators);

¾ number of tests per aeration setting;

¾ method of test evaluation, if the method recommended in this standard is not to be applied;

¾ permissible deviation of test results from guaranteed values.

7.3 Filling of the tank with test-water

Prior to filling with water the tank shall be cleaned and the tank water volume shall be measured. In order to check the test water level(s) a mark shall be made at the tank wall.

After filling the tank to the desired level the aeration system and, if installed, the mixers, should be operated for at least 12 h before the start of testing.

If other than drinking water is used, at the end of the 12 h period and prior to testing, a sample shall be taken and analysed for total dissolved solids, electrolytic conductivity, dissolved organic carbon and surfactants.

After the aeration and mixers are switched off, the water level in the tank shall be checked. If surface aerators are tested, the water level shall not drop by more than 1 cm during a test.

If fine bubble diffused air aeration is used the aeration system should be operated for 24 h prior to testing in order to drain the pipes and to clean the diffusers.

7.4 Installation of the DO probes

The DO probes shall be installed at a minimum distance of 50 cm from the walls, the water surface and the tank bottom. DO probes should be installed in a way that the accumulation of air bubbles at the membranes is avoided, e.g. at an angle of 45°.

In completely mixed tanks, and those which are regarded as completely mixed, the DO probes may be installed at any location. In tanks with surface aerators the minimum of three probes shall be positioned at different representative depths.

In rectangular tanks with diffused air aeration the DO probes shall be distributed along the length of the tank. If the density of diffusers varies over the length of the tank, at least one probe shall be installed at the centre of each diffuser density section.

After installation of the DO probes, the aeration and if applicable the mixers shall be operated at the lowest setting to be tested. The readings of the oxygen concentration should indicate whether the turbulence at the probes is sufficient. If by the movement of a probe a higher value reading is indicated, the turbulence is insufficient. Agitators should then be employed to increase the turbulence at the probe.

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7.5 Addition of chemicals

7.5.1 Cobalt catalyst

The cobalt salt shall be dissolved in water before addition to the aeration tank. For all tests with the same water only one addition of cobalt is required.

The cobalt catalyst shall be added in such a way as to ensure an even distribution over the volume of the tank. After the addition of the cobalt, aeration and mixing shall be operated for at least 30 min in order to ensure even distribution.

NOTE The process of adding cobalt is avoided if desorption tests are carried out or if nitrogen gas is used to decrease the DO.

7.5.2 Sodium sulphite

Prior to the addition of sulphite the DO probes shall be installed and the DO shall be recorded.

Sodium sulphite may be added in either dissolved or powdered form. This shall be agreed upon by the client and the contractor or manufacturer.

The mass of sodium sulphite needed for one test (M_{So}, kg) depends on the tank volume (V, m³), the initial concentration of dissolved oxygen C_{i} and the mixing period t_{M} required to establish constant mixing and flow conditions at zero dissolved oxygen concentration and whilst aeration is operated at the desired setting SOTR. It shall be calculated as follows:

$$M_{\mathrm{So}} = 8 \quad [(V \quad C_{\mathrm{i}} / 1\,000) + (t_{\mathrm{M}} \quad SOTR / 60)] \tag{8}$$

The tank used to dissolve sodium sulphite shall be equipped with an appropriate mixing device, this may be a mixer or a submersible pump. To dissolve 100 kg of sodium sulphite a minimum mixing tank volume of 1 m³ is required. Lumps of sodium sulphite which can develop in the mixing tank shall not be transferred to the aeration tank.

Possible procedures for sulphite addition are:

a) Addition of sodium sulphite without aeration. Appropriate mixing by either built-in or external mixers is required. With diffused air aeration, mixing may be performed by a low air flow rate. The addition of sodium sulphite in powdered form may only be performed if the mixing intensity is sufficient to prevent settling of sulphite powder. The mixing period t_{M} is the time required to establish constant mixing or flow conditions after aeration is switched to the setting to be tested.

b) Addition of sodium sulphite whilst aeration is operating at the desired setting. The mixing period t_{M} in this case is the time required to achieve an even distribution of sodium sulphite; it is dependent on the mixing characteristics of the tank, the aeration setting, the number of points and the time period of sulphite addition.

A uniform distribution of the sulphite concentration shall have been established by the time the dissolved oxygen concentration starts to rise. This should be checked by measuring the electrical conductivity at several points of the tank.

The following should be observed when procedure (b) is applied:

¾ Sulphite should be dosed in a continuous mode during a period of 4 min to 6 min simultaneously at all appropriate points. The number of dosing points shall be selected in order to achieve a uniform concentration of sulphite.

¾ Powdered sulphite shall be dosed in points with a high turbulence e.g. in tanks with surface aerators into the spreading zones.

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¾ In large tanks without bridges the distance between dosing points should not exceed 10 meters.

¾ In closed loop tanks sulphite should be dosed at one point with a constant rate for a period of 3 to 4 revolutions of the water. Multiple dosing points should be used for tanks with a revolution period of more than 15 min.

With diffused air aeration or vertical shaft surface aerators in completely mixed and rectangular tanks a period of t_M = 5 min may be sufficient if the sulphite addition is performed by procedure (a), if procedure (b) is used t_M = 10 min to 15 min may be required.

NOTE The process of adding sodium sulphite is avoided if desorption tests are carried out or if nitrogen gas is used to decrease the DO.

7.6 Gas injection

De-oxygenation by injection of nitrogen gas is restricted to aeration systems which have a very short mixing period. The method, therefore, can only be applied in completely mixed tanks or tanks with evenly distributed diffusers. It is preferable for the nitrogen gas to be injected through the air aeration system.

When de-sorption testing by raising the dissolved oxygen concentration beyond the (air) oxygen saturation concentration, the pure oxygen in addition to the air flow is injected into the air header. The ratio of oxygen to air determines the possible maximum dissolved oxygen concentration, which shall be 10 mg/l to 15 mg/l higher than the (air) oxygen saturation concentration.

7.7 Data collection during a test

A test shall commence with the start of the aeration system operating at the desired setting.

The signals from the DO probes during the initial phase should be observed in order to detect any anomalies. If not all DO probes are connected to a strip chart recorder or data logger, the values shall be registered at appropriate time intervals, which shall be no longer then 0,1/ $k_L a_T$. If a data logger is used, the time interval preferred is (1/60)/ $k_L a_T$.

The test is completed when the dissolved oxygen concentration is almost constant; the oxygen saturation value is reached.

Experienced institutions may shorten testing by measuring the oxygen saturation value after initial prolonged aeration and then finishing the tests at about $C = 0,8 \quad C_{S,p^*,T}$ (see annex A).

The following measurements shall be performed during any test:

¾ water level or the distance from the desired water level in the tank without aeration and mixing, or with surface aerators deactivated, shortly before and after the test (for surface aerators see 7.3);

¾ water temperature at the beginning and the end of the test. The average shall be used for the calculations;

¾ electrical power uptake at the beginning and at the end of the test. The average shall be used for the calculations;

¾ if applicable, the air flow rate at the beginning and at the end of the test. The average shall be used for the calculations;

¾ electrical conductivity of the water at the beginning and at the end of the test;

¾ ambient air temperature;

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¾ ambient air pressure;

¾ ambient air humidity to correct the measured airflow rate of blowers.

NOTE Photographs of the tank and the equipment used e.g. positions of DO probes, are useful.

7.8 Data analysis

The data from each DO probe between C 0, and C 0,99 $C_{S,p^*,T}$ which shall comprise at least 30 values of equal time interval shall be used for non-linear estimation of the oxygen transfer coefficient k_La_T and the oxygen saturation value $C_{S,p^*,T}$. The residues, calculated as C (measured) – C (calculated), shall be plotted. If the residues are not randomly distributed, stepwise data points from the beginning of the test or/and from the end of the test shall be neglected until the residues are randomly distributed.

In any case, the determination of k_La_T and $C_{S,p^*,T}$ shall be based on at least 30 values of equal time periods covering a total period of $3{,}5/k_La_T$ and at which at absorption testing the lowest oxygen concentration shall not be higher than $C_0 = 0{,}25\ C_{S,p^*,T}$ and at de-sorption testing the range of values ($C_0 - C_{S,p^*,T}$) shall cover more than 8 mg/l.

For each test the average of k_La_T shall be calculated. For tanks with different diffuser densities the volumetric weighted average shall be calculated.

For tanks with an even diffuser density, if single values of k_La_T deviate by more than ± 5 % from the average, the result from this probe shall be ignored.

If single values of $C_{S,p^*,T}$ deviate by more than ± 5 % from the average, the calibration of the DO probes shall be checked.

If the average value of $C_{S,p^*,T}$ is higher than the mid depth oxygen saturation value (equation 6) the latter shall be used in the calculation of the standard oxygen transfer rate.

If agreed upon by the client and the contractor or manufacturer, the mid depth oxygen saturation value may be used for the calculation of the standard oxygen transfer. Exact calibration of DO probes is then not necessary.

In accordance with equation (4), k_La_T and by equation (5), $C_{S,p^*,T}$ are adjusted for the standard temperature of 20 °C and 1 013 hPa. If mid depth oxygen saturation is agreed, equation (6) has to be used instead to calculate $C_{S,md,20}$. Finally equation (1), in which $C_{S,20}$ may be $C_{S,md,20}$, gives the standard oxygen transfer rate SOTR for the tested aeration setting.

If repeat tests have been carried out, the average standard oxygen transfer rate shall be the basis for compliance of the desired aeration setting.

8 Precision and accuracy of results

8.1 Standard oxygen transfer rate

In rectangular and circular tanks with equally distributed aeration devices and closed loop tanks with a circulation period shorter than $0{,}25/k_La_T$, the standard oxygen transfer rate (SOTR) can be determined with a precision of ± 5 %. In large closed loop tanks and large rectangular tanks ($V > 3\ 000\ m^3$) with an unequal distribution of the aeration devices the standard oxygen transfer rate can vary from test to test by up to ± 10 % mainly due to an uneven distribution of sodium sulphite.

8.2 Standard aeration efficiency

The total wire power can be measured with an accuracy of ± 3 % in accordance with 6.2.4. The standard aeration efficiency (SAE) is determined with an accuracy of ± 8 % and in large tanks up to ± 13 % (see 8.1).

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8.3 Specific standard oxygen transfer efficiency

The normal air flow rate Q_A depending on the quality of the metering device can be measured with an accuracy of ± 5 % (see 6.2.5). The specific standard oxygen transfer efficiency (SSOTE) is determined with an accuracy of ± 10 % and in large tanks up to ± 15 %.

9 Presentation and interpretation of the results

The test report shall include:

a) purpose of testing;

b) representatives of the client, the contractor and/or the manufacturer who were present on site during testing;

c) any agreed items, e.g. test water, mid-depth saturation, use of method given in annex A;

d) any agreed deviations from this standard;

e) description of the tank which was used for testing which may be illustrated by drawings and/or photographs showing the placement of the DO probes and the points at which the addition of sodium sulphite took place and, if applicable, the type and number of air diffusers;

f) description of the aeration installations and, if applicable, the mixers containing the name-plate data (A, kW, delivered air flow rate and pressure);

g) description of the equipment used for the measurements (e.g. DO probes, computer, recorder, data logger);

h) description of how the electrical power was measured and if applicable how the air flow rate was measured;

i) description of how sodium sulphite was added and the precise quantity added at each test;

j) overview of the tests which were performed, preferably as a Table containing the aeration settings, water levels and tank volumes and, if drinking water was not used, the results of the initial chemical analysis of the water and values of the electrical conductivity measurements before and after each test;

k) computer program which was used for the non-linear parameter calculation;

l) Table containing the values $k_L a_T$ and $C_{S,p^*,T}$ for each DO probe, the averages of each test, the standard oxygen transfer rate, the standard aeration efficiency of each test and the averages of replicate tests performed with the same aeration setting;

m) if requested by the client or the contractor or manufacturer, Tables or graphs showing the dissolved oxygen curves and the residues.

All data of the testing should be kept for a minimum of two years after reporting.

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Annex A
(normative)

Alternative test and evaluation procedure

A.1 Principle

By application of this procedure the time for testing can be shortened. The differences compared to the recommended method are:

¾ evaluation using linear regression (log deficit method) which requires precise calibration of the DO probes; and

¾ addition of dry (powdered) sodium sulphite.

This procedure shall only be performed by experienced institutions since on-site Winkler titration is required and DO probes of high long term stability shall be used.

For this procedure it is assumed that the test oxygen saturation value for a specific tank is constant at constant ambient conditions and independent from the aeration setting.

A.2 Measurement of the oxygen saturation value

Before testing, the saturation value (C_{S,p°,T°) shall be determined by Winkler titration (see EN 25813) after a prolonged aeration period of at least 12 h. The index $^{\mathbf{degree}}$ defines the ambient conditions at the time of sampling for Winkler titration.

A.3 In-situ calibration of the DO probes

The DO probes should be switched on at least 12 h prior to calibration which shall consist of the following three steps:

¾ pre-calibration in wet air;

¾ zero DO check for which the probes shall be placed in a solution of sodium sulphite;

¾ installation of the DO probes in the test tank. Calibration of the DO probes shall be performed using the previously determined oxygen saturation value C_{S,p°,T°.

A.4 Determination of the oxygen transfer coefficient

If the water temperature and/or the barometric pressure have changed, the test saturation value shall be calculated as follows:

$$C_{S,p^*,T} = C_{S,p^\circ,T^\circ} \quad (C_{S,St,T} / C_{S,St,T^\circ}) \quad (p \ / p^\circ) \tag{A.1}$$

The oxygen transfer coefficient is obtained by linear regression:

$$\ln(C_{S,p^*,T} \quad C_t) = \ln(C_{S,p^*,T} \quad C_0) \quad (k_L a_T \quad t) \tag{A.2}$$

At least 30 values of equal time distance shall be used for the determination of $k_L a_T$. The value of C_0 shall not be lower than 0,1 $C_{S,p^*,T}$. The highest value of C_t shall not exceed 0,8 $C_{S,p^*,T}$.

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Bibliography

European Standards

EN 752-6, *Drain and sewer systems outside buildings — Part 6: Pumping installations.*

EN 25813, *Water quality — Determination of dissolved oxygen — Iodometrical method (ISO 5813:1983).*

EN 12255-6, *Wastewater treatment plants - Part 6: Activated sludge process.*

Austria

OENORM M 5888, *Measurement of oxygen transfer of aeration equipment in clean water and activated sludge.*

Belgium

FUL (1995): Convention pour la normalisation d´essau d´airateurs; Rapport final, 124p.

France

Ministère de l´Equipement, du Logement et des Transports 96-7TO. Conception et execution d´installations d´èpuration d´eaux usèes. Fascicule n° 81 titre II.

Cemagref (1980), Les performance des systèmes d´aèration des stations d´èpuration. Mèthodes de mesures et rèsultats, 123 p.

Duchène, Ph., Schetrite, S., Heduit, A., Racault, Y. (1995). Comment rèussir un essai d´aèrateur en eau propre. Ed. Cemagref, Antony (France), 118 p.

Germany

ATV-M 209, Measurement of the oxygen transfer in activated sludge aeration tanks with clean water and in mixed liquor (in English). Published by GFA, Theodor Heuss Allee 17, D-53773 Hennef, Germany.

Other references

ASCE (1992): ASCE Standard, Measurement of oxygen transfer in clean water. Published by the American Society of Civil Engineers, 345 East 47th Street, New York, N.Y. 10017-2398, USA.

Philichi, T. L. and Stenstrom, M. K. (1989): Effects of dissolved oxygen probe lag on oxygen transfer parameter estimation. Journ. WPCF 61, 83.

Stenstrom, M. C., Brown, L.C., Hwang, H. J. (1981): Oxygen transfer parameter estimation. ASCE Jour. Environ. Engr. 107, EE2, 379

Terry, D. W. and Thiem, L. T. (1989): Potential interferences in catalysis of unsteady-state reaeration technique. Journ. WPCF 61, 1464.

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