SLOVENSKI STANDARD
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Ļistilne naprave za odpadno vodo - 15. del: Merjenje vnosa kisika v ļisto vodo v aeracijskih bazenih naprav z aktivnim blatom

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

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

Stations d'épuration - Partie 15: Mesurage du transfert d'oxygene en eau claire dans les bassins d'aération des stations d'épuration a boues activées

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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.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

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of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.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:

- *Part 1: General construction principles*
- *Part 3: Preliminary treatment*
- *Part 4: Primary settlement*
- *Part 5: Lagooning processes*
- *Part 6: Activated sludge process*
- *Part 7: Biological fixed-film reactors*
- *Part 8: Sludge treatment and storage*
- *Part 9: Odour control and ventilation*
- *Part 10: Safety principles*
- *Part 11: General data required*
- *Part 12: Control and automation*
- *Part 13: Chemical treatment — Treatment of wastewater by precipitation/flocculation*
- *Part 14: Disinfection*
- *Part 15: Measurement of the oxygen transfer in clean water in aeration tanks of activated sludge plants*
- *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.

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 α-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:

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

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]

[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.

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

or

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

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:

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

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:

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

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):

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

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)

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_La_{20} oxygen transfer coefficient at T = 20 °C, in 1/h

k_La_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:

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

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_La_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

[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.

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 $k_L a_T$ 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 $k_L a_T$ using a measured oxygen saturation value $C_{S,p°,T°}$, 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 $k_L a_T$ shall be higher than 20 times the aeration tank $k_L a_T$.

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