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Čistilne naprave za odpadno vodo – 6. del: Postopek z aktivnim blatom

Wastewater treatment plants - Part 6: Activated sludge process

Kläranlagen - Teil 6: Belebungsverfahren

Stations d'épuration - Partie 6: Procédé à boues activées

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Wastewater treatment plants - Part 6: Activated sludge process

Stations d'épuration - Partie 6: Procédé à boues activées

Kläranlagen - Teil 6: Belebungsverfahren

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 12255-6:2021) has been prepared by Technical Committee CEN/TC 165 “Waste water Engineering”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN-Enquiry.

This document will supersede EN 12255-6:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

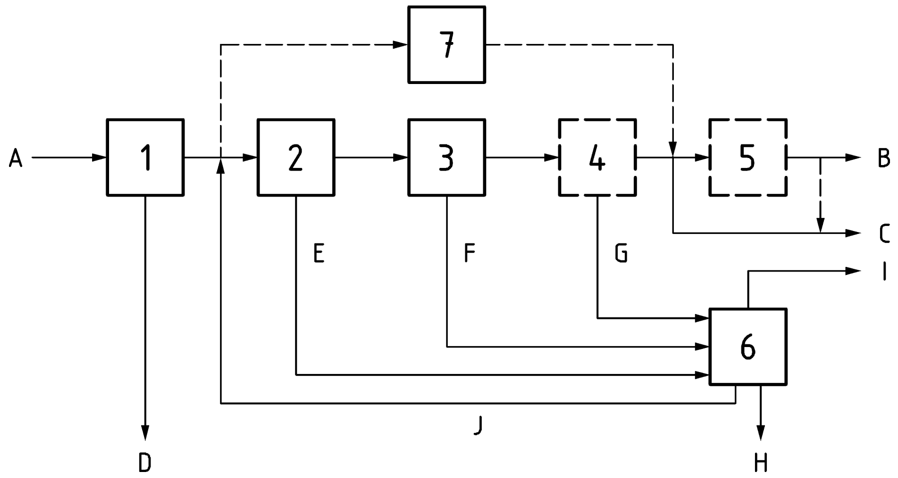
This is the sixth part prepared by Working Group CEN/TC 165/WG 40, relating to the general requirements and processes for treatment plants for a total number of inhabitants and population equivalents (PT) over 50.

The EN 12255 series with the generic title “Wastewater treatment plants” consists of the following Parts:

- *Part 1: General construction principles*
- *Part 2: Storm management systems*
- *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*

Introduction

Differences in wastewater treatment throughout Europe have led to a variety of systems being developed. This document gives fundamental information about the systems; this document has not attempted to specify all available systems. A generic arrangement of wastewater treatment plants is illustrated below:



Key

1 preliminary treatment
2 primary treatment
3 secondary treatment
4 tertiary treatment
5 additional treatment (e.g. disinfection or removal of micropollutants)
6 sludge treatment
7 lagoons (as an alternative)
A raw wastewater
B effluent for re-use (e.g. irrigation)
C discharged effluent
D screenings and grit
E primary sludge
F secondary sludge
G tertiary sludge
H digested sludge
I digester gas
J returned water from dewatering

Figure 1 — Schematic diagram of wastewater treatment plants

The primary application is for wastewater treatment plants designed for the treatment of domestic and municipal wastewater.

NOTE For requirements on pumping installations at wastewater treatment plants see EN 752 “Drain and sewer systems outside buildings” and EN 16932, “Drain and sewer systems outside buildings — Pumping systems”:

— *Part 1: General requirements;*

— *Part 2: Positive pressure systems;*

— *Part 3: Vacuum systems.*

1 Scope

This document specifies performance requirements for treatment of wastewater using the activated sludge process for plants over 50 PT.

A variety of activated sludge systems has been developed. This document has not attempted to specify all available systems. This document provides fundamental information about single stage systems.

The informative Annexes A, B and C provide design information.

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.

EN 16323, *Glossary of wastewater engineering terms*

EN 12255-1, *Wastewater treatment plants — Part 1: General construction principles*

EN 12255-10, *Wastewater treatment plants — Part 10: Safety principles*

EN 12255-11, *Wastewater treatment plants — Part 11: General data required*

EN 12255-12, *Wastewater treatment plants — Part 12: Control and automation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 16323 and the following apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
enhanced biological phosphorus removal
activated sludge system for increased biological phosphorus removal by luxury uptake whereby mixed liquor or return sludge is intermittently subjected to anaerobic and aerobic conditions

3.2
internal recirculation ratio
IRR
ratio of the flow of recirculated nitrate containing wastewater to a denitrification reactor relative to the inflow

3.3
selector
first, small reactor of an activated sludge system where incoming wastewater and return activated sludge are blended and mixed to subject the return activated sludge to a high sludge load in order to mitigate sludge bulking

Note 1 to entry: A selector can be aerobic or anaerobic; aerobic selectors are more common. An anaerobic selector can also be used to assist biological phosphorus removal.

3.4
mixed liquor suspended solids
MLSS
dry mass concentration of suspended solids in a mixed liquor

Note 1 to entry: the dry mass of filtered solids are determined in accordance with the 23rd, edition of Standard Methods for Wastewater (SMEWW), 2540 parts D & E.

[SOURCE: EN 16323:2014, definition 2.3.10.24]

3.5
mixed liquor volatile suspended solids
MLVSS
dry mass concentration of organic suspended solids in a mixed liquor

Note 1 to entry: the dry mass of filtered solids are determined in accordance with the 23rd, edition of Standard Methods for Wastewater (SMEWW), 2540 parts D & E.

[SOURCE: EN 16323:2014, definition 2.3.10.25]

4 Symbols and abbreviations

4.1 Symbols

Symbol	Definition	Unit
A	area	m²
C	mass concentration	mg/l
D	diameter	m
F	factor	(dimensionless)
F/M	load to mass ratio, (e.g. kg BOD5/d per kg MLSS)	kg/(kg·d)
HRT	hydraulic retention time (= V/Q)	d
IRR -	internal recirculation ratio (for recirculation of nitrate)	(dimensionless)
L	length	m
M	mass	kg
MSRT	mean solids retention time = sludge age	d or h
OC	oxygen consumption	kg/h
OTE	oxygen transfer efficiency at operational conditions	kg/kWh
P	power	W or kW
Q_x	specific flow per x, e.g. per person	$m^3/(h·x)$
Q	flow	m^3/h or l/s
RSR	return sludge ratio = return sludge flow to wastewater inflow	(dimensionless)
S	dissolved mass concentration	mg/l
SOTR	standard oxygen transfer rate	kg/h

Symbol	Definition	Unit
SSOTR	specific standard oxygen transfer rate	$g/(Nm^3 \cdot h)$
SOTE	standard oxygen transfer efficiency	kg/kWh
SSOTE	specific standard oxygen transfer efficiency	%/m
SSP	surplus sludge production	kg/d
SVI	sludge volume index	ml/g
SSVI	stirred sludge volume index	ml/g
T	temperature	°C or K
V	volume	m^3
W	width	m
X	solid mass concentration	mg/l
Y	yield	kg/kg
a	number of scraper arms	—
c	concentration	mmol/l
h	height or depth	m
l	specific load per person or total population and day	g/(P·d)
n	number	—
p	pressure	kPa
t	time	h or s
v	velocity	m/s
α	alpha factor = ratio of oxygen transfer coefficients in wastewater to test water	—
β	salinity factor of test water	—
Δ*p*	pressure loss	kPa

4.2 Indices

A area

Air air

Al aluminium

Al(III) trivalent aluminium (Al^{3+})

AR aerobic reactor

BioP enhanced biological P removal

B bottom

Bl blower

BM biomass

BOD_5 biochemical oxygen demand in 5 days

C	carbon
CH_4	methane
Cl	clarifier
CO_2	carbon dioxide
COD	chemical oxygen demand
D	depth
Den	denitrification
Dif	diffuser
Dos	dosing
DS	dried solids
EPDM	ethylene-propylen-dien class M; a synthetic rubber material
Fe	iron
Fe(II)	bivalent iron (Fe^{2+})
Fe(III)	trivalent iron (Fe^{3+})
F	floor
MAP	magnesium-ammonium-phosphate, also called struvite
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
N	nitrogen
Nitr	nitrification
NH_4	ammonium
NO_3	nitrate
N_2O	nitrous oxide or laughing gas
O_2	oxygen
OTC	oxygen transfer concentration
OT	oxygen transfer
P	phosphorus
PE-HD	polyethylene with high density
PL	pipeline
PostD	post-denitrification
PreD	pre-denitrification
PP	polypropylene
PT	total population = population + population equivalents
PVC	polyvinylchloride
R	reactor
RS	return sludge

SA	solids per area
SBR	sequencing batch reactor
S	sludge
SC	shortcut
Scr	scraper
SimD	simultaneous denitrification
SR	sludge return
SS	suspended solids
St	standard
T	temperature dependent
TDS	total dissolved salt
TKN	total Kjeldahl nitrogen
TW	test water
WW	wastewater
WWTP	wastewater treatment plant

4.3 Abbreviations

alk	alkalinity
amb	ambient
bw	backward
cy	cycle
dis	dissolved
deg	degradable or degraded
des	design
fw	forward
geo	geodetic
hor	horizontal
h	hourly
im	immersion
in	inflow
inert	not degradable
inorg	inorganic
int	intermittent
max	maximum
min	minimum
org	organic or volatile

orgN	organic nitrogen
out	outflow
p	particulate
prec	precipitated
redeg	readily degradable without the need for prior hydrolysis, available for denitrification
sal	salinity
sat	saturation
th	thickening
tot	total
vert	vertical
20	20 °C

5 Requirements

5.1 General

Biological reactors and final clarifiers are connected by return sludge recirculation lines and form a unit process: the activated sludge process. The performance of the process depends on biological and chemical reactions in the activated sludge tanks as well as separation of activated sludge in the final clarifiers. Activated sludge systems include structures, such as aeration basins and sedimentation tanks, and technical equipment, such as aeration systems and sludge scrapers.

Biological treatment and clarification (decanting) may be combined in a single sequencing batch reactor (SBR) with intermittent aeration and sedimentation.

The design shall take account of the requirements specified in EN 12255-1, EN 12255-10, EN 12255-11 and EN 12255-12.

5.2 Planning

5.2.1 Basic information

The design of an activated sludge system shall be based on at least the following information:

1. Maximum and minimum wastewater temperature and temperature-dependent requirements on the effluent quality;

2. Maximum, minimum and yearly average wastewater inflow; and the maximum 2 h-inflow during dry weather conditions;

3. System loads, depending on primary treatment (where provided), including variations of COD (or BOD), SS, P and TKN concentrations. The 85 %-quantiles should be provided for system design and the 50 %-quantiles (i.e. medians) or arithmetic averages should be provided for the calculation of operating costs and the design of sludge treatment facilities;

4. Where possible, the composition of the incoming COD shall be provided to the designer, separated into degradable dissolved COD, inert dissolved COD, degradable particulate COD, inert particulate COD and readily degradable COD;

   NOTE With the standard methods, COD is analysed using dichromate as the oxidising agent. Chrome is a heavy metal. It would be more sustainable if dichromate could be replaced with a different oxidising agent.

5. A minimum of 40 samples shall be analysed for all parameters;

6. The consent standards concerning COD, N and P concentrations in the effluent.

Return loads from sludge treatment shall be taken into account, particularly ammonium return load. In some cases, it may be necessary to provide separate treatment of filtrate or centrifugate from sludge dewatering, e.g. using a de-ammonification process.

Load removal ratios during primary treatment shall be taken into account. It is recommended to investigate the removal ratios during dry weather conditions. Where this is not feasible, removal ratios as shown in Annex C may be used.

Biological treatment units should be protected from excessive hydraulic loads e.g. by the use of overflow devices and/or storm tanks to meet the required discharge consent. The frequency and volume of wastewater discharges should be limited (see EN 752).

It is recommended that a half-technical pilot test is performed for a minimum period of half a year (including the cold weather period) to investigate data for the system design. A design based on long-term testing can optimize the design and avoid safety factors necessarily included in a more general design.

Where this is not feasible, Annex A provides basic guidance information for system design.

The following factors shall be determined during planning of an activated sludge system:

- capacity and dimensions of the biological reactors;
- prevention of dead zones and of detrimental deposition in tanks/channels;
- establishment of multiple lines/units or other technical means to maintain the required final effluent quality while maintenance or repair work is carried out;
- aeration and/or mixing equipment in the biological reactors with sufficient capacity;
- surface area, volume and depth of final clarifiers;
- sludge removal system within clarifiers;
- sludge recirculation and surplus sludge wasting equipment;
- internal recirculation ratio and equipment;
- sufficient stabilization of the removed surplus sludge (where required);
- measurement and control systems;
- odour control;
- noise and vibration control;
- hydraulic head loss.

5.2.2 System selection

The configuration, number, shape and volume of reactors achieving the main biological reactions can vary considerably according to:

- plant size;

- the quality of treatment to be achieved, e.g. only BOD removal, nitrification, denitrification and/or phosphorus removal;
- the requirement for simultaneous aerobic sludge stabilization (i.e. the required aerobic sludge age);
- selection of a single-stage or multi-stage system;
- where biological nitrogen removal is required: selection of the type of denitrification (e.g. pre-, cascade-, simultaneous, alternative, intermittent or post-denitrification);
- provision of anaerobic or aerobic selectors to mitigate sludge bulking;
- provision of anaerobic reactors to achieve enhanced biological phosphorus removal;
- provision of reactors which can use anoxic or aerobic treatment (depending on load and temperature);
- requirement for chemical phosphate removal by addition of metal salts (e.g. of ferric, ferrous or aluminium salts);
- minimum and maximum temperatures, and temperature dependent requirements (e.g. N-removal requirements).

Where biological nitrogen removal is required, nitrification and denitrification reactors shall be provided. Six systems can be distinguished (see Figure 1):

1. pre-denitrification in one or several anoxic reactors which are (usually) not aerated;
2. cascade denitrification with alternating anoxic and aerobic reactors whereby the inflow is fed to anoxic reactors;

3. simultaneous denitrification in a loop reactor (oxidation ditch) with alternating aerobic and anoxic zones;
4. alternating denitrification with parallel reactors that are sequentially aerated and non-aerated, whereby the inflow is always fed into the non-aerated reactor;
5. intermittent aeration providing for a sequence of aerobic and anoxic conditions within a reactor, e.g. in an SBR-reactor; intermittent aeration requires a substantially higher capacity of the aeration system;
6. post-denitrification with a carbon source fed into the anoxic reactor, followed by a post-aeration reactor (this system may be used where the C/N-ratio in the influent is so low that a carbon source shall be added anyway).