Wastewater treatment plants —

Part 6: Activated sludge process

The European Standard EN 12255-6:2002 has the status of a British Standard

ICS 13.060.30

National foreword

This British Standard is the official English language version of EN 12255-6:2002.

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

— aid enquirers to understand the text;

— present to the responsible 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

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 165, Wastewater 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of an identical text or by endorsement, at the latest by July 2002, and conflicting national standards shall be withdrawn at the latest by December 2002.

In this standard the Annex A is informative.

It is the sixth 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. The parts of the series are as follows:

- *Part 1: General construction principles*
- *Part 3: Preliminary treatment*
- *Part 4: Primary settlement*
- *Part 5: Lagooning processes*
- *Part 6: Activated sludge processes*
- *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*[1)]

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*.

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).

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, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

[1)] In preparation.

1 Scope

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

Differences in wastewater treatment throughout Europe have led to a variety of systems being developed. This standard gives fundamental information about the systems; this standard has not attempted to specify all available systems.

Detailed information additional to that contained in this standard may be obtained by referring to the bibliography.

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 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.*

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

3 Terms and definitions

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

4 Requirements

4.1 General

The biological reactors and the clarifiers connected by the return sludge recirculation form a unit process: the activated sludge process. The performance of the process depends on the biological and chemical reactions in the activated sludge tanks as well as the separation of the activated sludge in the final clarifiers.

NOTE Biological treatment and clarification may be combined in the same tank, e.g. a sequencing batch reactor (SBR).

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

4.2 Planning

The following factors shall be considered in the design of an activated sludge treatment plant:

- the capacity and dimensions of the biological reactors;
- the prevention of dead zones and detrimental deposition in tanks/channels;
- the establishment of multiple lines/units or other technical means to ensure maintenance of required final effluent quality if one or more line/unit is out of operation;
- the aeration and/or mixing equipment;
- the surface area, volume and depth of the clarifiers ;
- sludge removal system within the clarifier;
- the sludge recirculation and excess sludge wasting equipment;
- the treatment and final destination of the sludge produced;
- measurement and control;
- the head loss to be minimized.

The structures shall be designed to allow emptying either by gravity flow or by pumping. Emptying shall not affect the stability of structures, irrespective of the groundwater level. All necessary measures shall be taken such as ballast concrete, floor check valve or provision for temporary lowering of the groundwater.

It can be useful to design the floor to slightly incline towards the lowest points.

When a pump is used for emptying a drain pit may be built into these low points.

4.3 Flow-splitting structure

When the process involves multiple lines or parallel units, the incoming flow shall be distributed by an adjustable distribution device (e.g. valve, gate, stop-log) that can also be used to isolate each treatment unit.

This device shall provide the required flow distribution over the range of flow rates considered.

NOTE The accumulation and removal of floating matter can be considered at this stage.

4.4 Biological reactor

4.4.1 Design

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

- the size of plant;
- the level of treatment to be achieved, e.g. carbonaceous removal, nitrification, denitrification and phosphorus removal;
- the anoxic stage, with respect to nitrogen removal;
- the dosage of precipitant and/or the anaerobic stage with respect to phosphate removal.

The hydraulic design shall minimize short-circuiting. The reactor flow pattern depends on the process selected. In the case of multipoint feed (e.g. step-aeration), appropriate devices (e.g. valves, gates, stop-logs) shall be provided to allow modification of the original flow-splitting arrangement.

When the plant is designed for one or more reactors to be taken out of service for routine maintenance, the reactors remaining in operation and their associated pipework, channels, etc., shall have the hydraulic and treatment capacity to accommodate all the incoming flow.

A selector where return sludge and wastewater are brought into a short period of contact can reduce the growth of filamentous bacteria and improve the growth of flocculant bacteria. Owing to the short contact time, the content shall be mixed efficiently. Where intermittent pumping exist the influent and return sludge shall arrive at the same time.

4.4.2 Operational parameters

The following operational parameters shall be considered and should be appropriate for the level of treatment required:

- the mixed liquor suspended solids concentration (MLSS) or the mixed liquor volatile suspended solids (MLVSS);
- the sludge age;
- the sludge loading (F/M);
- the sludge volume index (SVI) e.g. stirred (SSVI) or diluted.

NOTE Further information is available in the references listed in the Bibliography.

4.4.3 Mixing

Mixing can be performed by the aeration devices themselves (e.g. surface aerators, air-diffusers), by separate mixing devices or by the two together. Individual mixing devices should be capable of being removed without emptying the tank. The contents of the aeration tank shall be mixed to prevent activated sludge from settling or forming detrimental deposits.

If aeration is not continuous, the devices shall have the capacity to maintain or resuspend the mixed liquor.

Mixers should be designed to minimize fouling by fibrous materials.

The choice of device depends on the characteristics of the wastewater to be treated and the mixed liquor concentration required. More powerful devices can be required in cases where the activated sludge process is not preceded by primary settlement.

4.4.4 Aeration

In the absence of complementary mixing devices, aeration devices shall have the capacity to provide sufficient agitation to thoroughly mix the biomass, the pollutants and the dissolved oxygen.

The dimensioning of the aeration devices and the tanks should ensure both the adequacy of mixing of the activated sludge mixed liquor and the energy efficiency of the process.

If pure oxygen is used in aeration:

- all necessary safety precautions shall be taken;
- explosive gas monitoring and explosion proof equipment shall be provided;
- specific safety signs shall be displayed.

It shall be verified that the power input of the aeration device, derived from aeration requirements, is not lower than the power required to ensure adequate mixing conditions at all times (unless alternative arrangements are in place for the mixing process).

Air diffusers shall be installed to ensure a uniform depth of immersion.

The aeration system shall have the capacity to supply sufficient oxygen to ensure carbonaceous oxidation, endogenous respiration and oxidation of nitrogen compounds (if these are required) under all operating conditions. The basis of the design is clean water oxygen transfer capacity which shall be calculated for the maximum and minimum oxygen uptake rate, considering the alpha factor which depends on the wastewater characteristics and the type of aeration system.

In order to maintain the desired dissolved oxygen level, a variable oxygen supply should be provided where possible, especially where a large variation in oxygen demand is anticipated.

NOTE The requirement for the oxygen supply is dependent on the wastewater characteristics and the level of treatment to meet the consent standards.

When aeration is not controlled by on-line measurements the operation of the aeration device(s) may be programmed with settings for rate, interval and duration. For nitrification/denitrification in a single reactor, the power of the aeration devices shall be compatible with their duration of operation.

The automatic control system shall be designed to ensure adequate aeration is maintained in case of its failure.

Where dissolved oxygen control is achieved by variation of mixed liquor level, using an adjustable weir, the surge flows into the clarifiers shall be taken into consideration.

Where automatic controls are used the system shall be designed to change into safe state (fail-safe mode) in case of failure.

The aeration system, shall be designed to operate under the most severe on-site conditions (e.g. extreme temperatures, inclement weather, corrosive atmosphere).

Unless otherwise agreed, the design service life of the equipment for aeration (see also EN 12255-1) shall be:

- Class 5: for gears and bearings of surface aerators;
- Class 3: for all electrical motors;
- Class 4: for additional mixing devices.

In fine-bubble aeration systems, the process air shall be thoroughly filtered to remove dust particles and oil as these can cause blockage of the aeration device/s. Where penetration of mixed liquor into the diffuser is possible on loss of air pressure, intermittent operation shall not be performed. If a build-up of calcium carbonate at the diffuser is expected the process shall incorporate a suitable means of cleaning with acid.

The utilization factor (see EN 12255-1*)* for the layout of gears and bearings of surface aerators shall be $K_A = 2$. Rotor blades and main shafts should be laid out according to fatigue strength at nominal load. The maximum deflection of shafts on horizontal aerators caused by load and weight should be less than $^1/_{1000}$ of shaft length.

The aeration system shall have some form of standby equipment, either built-in or in store.

Documentary evidence of the performance of the aeration system shall be provided, which should include the following:

- the characteristics and dimensions of the test aeration tank with the aeration system built in;
- the test procedure used;
- the test protocol;
- the nominal oxygen transfer capacity;
- the nominal oxygen transfer efficiency.

NOTE In situ performance testing can be required (see EN 12255-11 and prEN 12255-15).

4.4.5 Additional considerations

Biological treatment should be protected from excessive hydraulic loads e.g. by the use of overflow devices and/or storm tanks to meet the required discharge standard.

The water level in the biological reactors can be controlled by fixed or adjustable weirs.

The freeboard of aeration tanks shall be of sufficient depth to prevent overflowing of mixed liquor or foam under normal operational conditions.

The wave effect is amplified by hydraulic resonance phenomena which can be significant. Particular caution is required in tanks with surface aerators.

Foam of varying stability and viscosity can develop and be colonized by filamentous microorganisms. To control the factors that are favourable to physical/chemical and biological foaming (i.e. those that cause a build-up of volatile fatty acids and surface-active products in the biological reactor), the number of possible points of accumulation shall be minimized.

Fixed scum baffles should be avoided. Temporarily submerged weirs and accessible draw off devices should be provided.

Provision should be made for the removal or the transferring of floating matter and/or biological foam.

Degassing may be achieved in a flow-splitting chamber.

Degassing structures may be used to improve subsequent clarification by removing gas bubbles from the mixed liquor, especially in the case of deep aeration tanks. It is also an appropriate location to remove floating matter.

The surface area and the volume of the degassing structure shall be sufficient to guarantee efficient separation of liquid and gaseous phases up to the maximum expected flow rate.

These structures should be installed between the biological reactors and the clarifiers, preferably as close as possible to the latter.

All emissions associated with the reactors shall comply with national requirements. Sound proofing and resonance reduction shall be considered for the following:

— blowers, silencers and associated air distribution pipework;

— motors and gearboxes on surface aerators.

The control of spray from surface aerators shall be considered.

In diffused air systems consideration shall be given to the limiting of air velocity to minimize noise and dynamic head loss. Heat generated in the pipework shall also be a safety consideration.

In the majority of cases covering will not be necessary. In cases where the biological reactors are covered (e.g. for environmental reasons), the materials used shall be capable of withstanding the aggressiveness of the environment which will be increased proportionately by the arrival of potentially septic wastewater or industrial effluents. The walls above the water level shall also be protected down to 0,3 m below the lowest operating level of liquid.

Mechanical ventilation shall be considered to limit the aggressiveness of the atmosphere and increase the service life of structures and equipment. Such a system shall be installed if staff operate within the enclosed space.

Where vertical shaft surface aerators are used, consideration shall be given to the prevention of cavitation eroding the bottom surface of the tanks.

4.5 Clarifiers

4.5.1 General

The clarifiers shall achieve the required separation of the activated sludge solids from the effluent and provide a concentration zone for withdrawal of sludge for re-circulation. The efficiency of separation affects the quality of the final effluent and the concentration of the return sludge.

Clarifiers can be upward flow, horizontal flow or lamella separator (see EN 12255-4 for description).

NOTE In a SBR, clarification is implemented in the reactor and no return sludge system is needed.

For general construction principles and the design service life of equipment within clarifiers see EN 12255-1.

4.5.2 Design

In addition to the type of process planned and the required efficiency of separation, the sizing parameters also depend on the type of clarifier, and notably the maximum admissible settling rate. This rate takes into account the specific hydraulic characteristics of both upward flow and horizontal flow clarifiers, and whether or not they are equipped with lamella modules.

Particular attention shall be given to the surface loading rate required for the effective operation of clarifiers.

In all cases, the settling area depends on the following:

- settleability of the sludge expressed by its index;
- concentration of incoming mixed liquor;
- required output performance;
- shape and depth of the clarifier.

The clarifier shall be sufficiently deep to store sufficient quantities of sludge for all hydraulic conditions (duration and value of minimum and maximum flow rates).

A clarifier has four main zones: inlet, settling (clarification), effluent collection and sludge concentration and collection.

The inlet zone shall ensure:

- dissipation of input energy to sustain flocculation;
- even distribution;
- degasification (see 4.4.5).

The settling zone shall be designed to ensure a sufficient surface area and depth for the settlement of activated sludge flocs to minimize short-circuiting.

The effluent collection zone shall be designed to ensure:

- uniform and slow draw-off of effluent from the settling zone;
- retention of and the facility for removal of floating matter;
- minimum sludge carry over.

The sludge concentration and collection zone shall be designed to ensure the concentration and storage of sludge solids.

The collection and removal of sludge shall be arranged according to the size and type of clarifier.

Where a hopper is installed the angle of slope of the sides measured from the horizontal shall not be less than 50° for conical and 60° for pyramidal hoppers.

For small units, sludge can be collected by gravity flow, by means of steeply inclined (50° respectively 60°) floors and as smooth a surface as possible.

For larger clarifiers with flat or with slightly inclined floors, a scraping or removal device is necessary, such as one of the following types:

- scraper blades to move sludge towards a point at the centre (circular structure) or at the edge (rectangular structure);
- suction devices fixed to travelling bridges to remove the sludge from the bottom of the tank.

The removal device shall be designed to ensure rapid sludge recovery, to maintain the required MLSS and to avoid anaerobic conditions. The velocity of the scraping device where used shall be low enough to minimize turbulence.

A device for the collection and removal of floating sludge and scum should be installed.

4.6 Return and surplus sludge systems

The return activated sludge system takes sludge from the clarifier(s) back to the reactor(s) in order to maintain the mixed liquor concentration required for the biological process.

The system should be designed to allow variation of the return sludge flow. The equipment and controls effecting this variation shall do so without causing rapid variation in the return sludge flow.

If biological reactors immediately preceding the clarifiers are of different types and sizes, independent return sludge systems can be required.

The return activated sludge may be transferred by centrifugal pumps, positive displacement pumps, screw pumps, air-lifts or any other system able to control the required flowrate. The system should be designed to minimize aerating the return sludge where an anaerobic or an anoxic zone is incorporated.

The system shall have standby facilities which may be a portable pump in the case of small treatment plants.

Surplus sludge formed during the biological process is removed in order to maintain the MLSS concentration in the biological reactors at the required level.

The mass and volume of sludge to be wasted depends primarily on the wastewater composition, the type of process and the sludge age required.

Sludge can be wasted either from the return sludge or as mixed liquor from the biological reactors.

The wasting of surplus sludge shall take into consideration further sludge processing.

Annex A
(informative)

Design-Technical process characteristics

Table A.1 — Typical process design values

Treatment required	Type of Process	F/M kg/(kg·d)	Design MLSS g/l	Sludge age days
Partial treatment	High rate or very high rate	≥ 1,0	1,5 to 2,0	≤ 1
Carbonaceous oxidation [a]	Conventional medium rate	0,25 to 0,5	2,0 to 3,0	2 to 4
Nitrification [a]	Low rate	0,10 to 0,15	3,0 to 5,0	7 to 12 [c]
Nitrification [b] and denitrification [a, b]	N-removal	0,07 to 0,09	3,0 to 5,0	12 to 15 [c]
Aerobic sludge stabilization [a, b]	Extended aeration	0,04 to 0,07	3,0 to 5,0	15 to 30 [c]

[a] For phosphate removal anaerobic contact period of 0,5 h to 2 h and/or appropriate dosage of precipitant is required.

[b] For nitrogen removal an anoxic fraction of reactor 0,2 to 0,5 is required.

[c] These values are valid for temperatures of 10°C and above.

Bibliography

The following documents contain details which can be used within the framework of this standard.

This list of documents which are published and used by the members of CEN was correct at the time of publication of this European Standard but should not be considered to be exhaustive.

European Standards

EN 12255-4, *Wastewater treatment plants — Part 4: Primary settlement.*

prEN 12255-15, *Wastewater treatment plants — Part 15: Measurement of the oxygen transfer in clean water in activated sludge aeration tanks.*

France

[1] Ministère de l'Equipement, du Logement et des Transports 96-7TO; *Conception et exécution d'installations d'épuration d'eaux usées*, Fascicule n^{o} 81 titre II.

Germany

[2] E DIN 19551-1, *Wastewater treatment plants — Rectangular tanks — Part 1: Settlement tanks with sludge scraper, suction type sludge remover and chain scraper; types, main dimensions, equipment.*

[3] E DIN 19552, *Wastewater treatment plants — Circular tanks — Settlement tanks with sludge scraper, suction type sludge remover and thickener; main dimensions, equipment.*

[4] E DIN 19558, *Wastewater treatment plants — Outlet installations, weir and scum baffle, submerged effluent pipes in tanks — Construction principles, main dimensions, layout.*

[5] E DIN 19569-2, *Wastewater treatment plants — Principles for the design of structures and technical equipment — Part 2: Specific principles for the equipment for separating and thickening of solids.*

[6] E DIN 19569-3, *Wastewater treatment plants — Principles for the design of structures and technical equipment — Part 3: Specific principles for the equipment for aerobic biological wastewater treatment.*

[7] ATV-A 122, *Principles for dimensioning, construction and operation of small sewage treatment plants with aerobic biological purification stage for connection values between 50 and 500 total numbers of inhabitants and population equivalents* [2)].

[8] ATV-A 126, *Principles for sewage treatment in sewage treatment plants according to the activated sludge process with joint sludge stabilization with connection values between 500 and 5000 total inhabitants and population equivalents* [2)].

[9] ATV-DVWK-A 131, *Bemessung von einstufigen Belebungsanlagen* (No English translation available) [2)].

[10] ATV-M 209, *Messung der Sauerstoffzufuhr von Belüftungseinrichtungen in Belebungsanlagen in Reinwasser und in belebtem Schlamm* (No English translation available)[2)].

2) Published by: Gesellschaft zur Förderung der Abwassertechnik e.V. (GFA) Theodor-Heuss-Allee 17, D - 53773 Hennef, Germany.

[11] ATV-Handbuch: *Biologische und weitergehende Abwasserreinigung, Kapitel 5, Belebungsverfahren*. Verlag W. Ernst und Sohn, Berlin und München, 1997 (No English translation available).

[12] ATV-Handbuch: *Mechanische Abwasserreinigung*. Verlag Ernst und Sohn, Berlin und München 4 Auflage 1997.

Switzerland

[13] VSA-Directive, *Small Sewage Treatment plants — Directive for the evaluation of the treatment processes and the design*. 1995.

United Kingdom

[14] *Manual of British Practice in Water Pollution Control Unit Processes, Activated Sludge*. 1987. The Institution of Water and Environmental Management.

[15] *Operating the Activated Sludge Process*. Hartley, Gutteridge, Haskins and Davey.

[16] *Water Treatment Handbook*. Degremont Volumes I & II, 6th Edition 1991.

National Annex NA (informative)

Design and Loading Data

NA.1 Introduction

Clause **4** of the standard gives guidance on the design of continuous activated sludge plants and sequencing batch reactors so as to highlight the main design considerations for each type of process. This annex gives more detailed information on the typical loading rates used for design of each process type depending on the main modes of operation.

Further information may be outlined from the Handbook of UK Wastewater Practice on activated sludge treatment [1]. The design of activated sludge plants to serve population equivalents of 1 000 or less is considered in more detail by the British Standard for design and installation of small sewage treatment works [2].

Typical loading rates are given in Annex A based on treatment of domestic wastewater at the normal range of temperatures in the UK (from 6 ºC in the winter up to 18 ºC in the summer). Lower loading rates may be required, if wastewater:

— contains significant levels of trade waste which inhibit biological treatment;

— has below average temperatures;

— is derived from a sewerage system subject to high levels of saline intrusion;

— has wide seasonal variations in flow and load.

NOTE Nutrients may need to be added if they are deficient at sites where wastewater contains a significant proportion of trade waste or arises from a catchment with soft water.

NA.2 Sequencing batch reactor

Table NA.1— Typical loading rates for sequencing batch reactors

Treatment required	Type of process	Sludge Loading kg/kg.d	Mixed liquor suspended solids mg/l	Sludge age d
Carbonaceous oxidation and nitrification	Low rate	0.05 to 0.15	2 000 to 6 000	8 to 20

NA.3 Final settling tanks

For the normal range of sludge settleability (SSVI of 50 to 120 ml/g) and mixed liquor solids concentrations (2 000 to 4 000 mg/l), the maximum surface loading rate usually lies in the range from 0.8 to 1.5 $m^3/m^2\cdot h$ and the sludge recycling ratio in the range of 0.5 to 1.2 D.W.F. The minimum retention time of each tank at dry weather flow (tank volume divided by dry weather flow) should be 6 h or more. For scraped tanks, floor slopes range from 14º (1 in 4) to 11º (1 in 5).

List of references

[1] Handbooks of UK wastewater practice. *Activated-sludge treatment* (second edition). 1997. Chartered Institution of Water and Environmental Management.

[2] BS 6297 (amended 1990), *Code of practice for design and installation of small sewage and treatment works and cesspools*.

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