SLOVENSKI STANDARD

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Sistemi za odvod odpadne vode in kanalizacijo zunaj zgradb - 4. del: Hidravlično dimenzioniranje in upoštevanje varstva okolja

Drain and sewer systems outside buildings - Part 4: Hydraulic design and environmental considerations

Entwässerungssysteme außerhalb von Gebäuden - Teil 4: Hydraulische Berechnung und Umweltschutzaspekte

Réseaux d'évacuation et d'assainissement a l'extérieur des bâtiments - Partie 4: Conception hydraulique et considérations liées a l'environnement

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 165 "Waste water engineering", the secretariat of which is held by DIN.

This part is the fourth in a series relating to the functional requirements of drain and sewer systems outside buildings that operate essentially under gravity. There will be seven parts, as follows: Drain and sewer systems outside buildings -

- Part 1: Generalities and definitions
- Part 2: Performance requirements
- Part 3: Planning
- Part 4: Hydraulic design and environmental considerations
- Part 5: Rehabilitation
- Part 6: Pumping installations
- Part 7: Operations and maintenance.

In drafting this part of this European Standard account has been taken of other available draft standards, in particular EN 476 "General requirements for components used in discharge pipes, drains and sewers for gravity systems".

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of an identical text or by endorsement, at the latest by March 1998, and conflicting national standards shall be withdrawn at the latest by March 1998.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, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard is applicable to drain and sewer systems, which operate essentially under gravity, from the point where the sewage leaves a building or roof drainage system, or enters a road gully, to the point where it is discharged into a treatment works or receiving water.

Drains and sewers below buildings are included provided that they do not form part of the drainage system of the building.

This part sets out the principles which shall be followed for both the hydraulic design and consideration of environmental impact of drain and sewer systems that operate essentially under gravity.

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.

EN 752-1 Drain and sewer systems outside buildings - Part 1: Generalities and definitions.

3 Definitions

For the purposes of this standard the following definitions, together with those given in EN 752-1, apply:

3.1 aerobic: Conditions in which dissolved oxygen is present.

3.2 aesthetic pollution: Aspects of pollution sensed by sight or smell, e.g. floating solids, oil films or bankside litter.

3.3 anaerobic: Conditions in which free oxygen is not present.

3.4 biochemical oxygen demand (BOD): Mass concentration of dissolved oxygen consumed under specific conditions by the biological oxidation of organic and/or inorganic matter in water.

3.5 depression storage: Precipitation retained in surface hollows which does not contribute to runoff.

3.6 flow balancing: Reduction in peak discharge by means of temporary storage of flow.

3.7 hydro-biological stress: Detrimental impact on aquatic flora and fauna, caused by high flow velocity and scour.

3.8 rainfall intensity: Depth of rain falling in unit time, i.e. volume of rain falling in unit time per unit area.

3.9 roughness: The frictional resistance of the surface of a pipe or channel under turbulent flow.

3.10 self-purifying capacity: Ability of receiving waters to recover from pollution by natural processes.

3.11 sub-critical flow: State of flow when the water velocity is less than the velocity of the small surface wave, water levels tending to be stable.

3.12 super-critical flow: State of flow when the water velocity is greater than the velocity of the small surface wave, violent fluctuations in water level being possible.

3.13 time of concentration: Time taken for runoff to travel from the hydraulically most distant point of the catchment area to a defined point in the drain or sewer.

3.14 **vortex manhole:** Circular manhole within which a large difference in level is accommodated by the sewage entering tangentially and descending helically.

4 Sources of additional information

This Standard sets out the essential requirements for good practice in various engineering activities relating to the planning, design and operation of drain and sewer systems. For supplementary detail and guidance reference should be made to national documents until such time as fully comprehensive European Standards are available.

The documents listed in annex A contain details which may be used in the framework of this part, given approval by the relevant authority.

5 Protection from surcharge and flooding

Design shall provide protection against flooding and surcharge from storms of predetermined intensities and frequencies taking into account backwater levels.

Surcharging is undesirable in wastewater drain and sewer systems.

6 Protection from pollution

The quality, quantity and frequency of any discharge to a receiving water from any sewer including a surface water sewer, combined sewer overflow, pumping installation or treatment works shall meet the requirements of the relevant authority. Design shall be such that the receiving water will be protected against overloading of its self-purifying capacity. It shall take account of physical, chemical, biochemical, bacteriological, aesthetic and any other relevant considerations.

7 Protection from septicity

Septicity within a drain or sewer system is undesirable and therefore shall be minimised. It will affect the sewage treatment process and can lead to the production of hydrogen sulfide (H_2S). Hydrogen sulfide is toxic and potentially lethal. Depending on its concentration, it is noxious, malodorous and, when oxidized to sulfuric acid, will tend to attack some materials in pipelines, treatment works and pumping installations. Parameters on which the concentration of hydrogen sulfide depend, and which shall be taken into account include:

- -temperature;
- -biochemical oxygen demand (BOD);
- -sulfate availability;
- -retention time in the sewer system;
- -velocity and turbulence conditions;
- -pH;
- -ventilation within the sewer system;
- -existence of rising mains or particular trade effluent discharges upstream of the gravity sewer.

Predictive equations can be applied in order to quantify sulfide formation both in pressure and gravity sewers.

Sulfide production may be controlled by providing adequately high velocities, small enough retention times and sufficient ventilation to achieve aerobic conditions within the liquid. Other remedial measures may include air injection, oxygen injection or chemical addition (with chemicals such as hydrogen peroxide, nitrates, iron sulfate or other metal salts). The choice of chemicals shall take into account their potential environmental impact.

8 Self cleansing velocities

The build up of permanent deposits of solids in drains or sewers can significantly increase the risk of flooding and pollution. Drains and sewers shall be designed to provide sufficient shear stress to limit the build up of solids to levels which do not significantly increase this risk.

For small diameter drains and sewers (less than DN 300) self-cleansing can generally be achieved by ensuring either that a velocity of at least 0,7 m/s occurs daily, or that a gradient of at least 1:DN is specified. In the case of drains, steeper gradients may be required by the relevant authority.

Where self cleansing velocities cannot be achieved provision should be made for adequate maintenance activities.

For larger diameter drains and sewers, higher velocities can need to be achieved particularly if relatively coarse sediment is expected to be present.

Local guidance, in the form of tables or equations may be available in national reference documents and should be used.

9 Hydraulic calculations

9.1 Velocity equations

9.1.1 General

Two equations are recommended for use in calculating turbulent flows in drains and sewers: Colebrook-White[1] and Manning[2].

[1] This equation is named Colebrook in the French version and Prandtl-Colebrook in the German version.
[2] This equation is named Manning-Strickler in the French and German versions.

9.1.2 The Colebrook-White equation

For circular pipes flowing full, the velocity of flow, v, is given by the equation:

$$v = -2 \cdot \sqrt{2gDJ_E} \cdot \log_{10}\left(\frac{k}{3{,}71\,D} + \frac{2{,}51\,\nu}{D\sqrt{2gDJ_E}}\right) \tag{1}$$

where:
- v is the velocity averaged across the flow cross-section, in metres per second;
- g is the gravitational constant, in metres per second squared;
- D is the internal pipe diameter, in metres;
- J_E is the hydraulic gradient (energy loss per unit length), dimensionless;
- k is the hydraulic pipeline roughness, in metres;
- ν is the kinematic viscosity of fluid, in metres squared per second.

For partially full pipes or pipes with non-circular cross-sections the velocity of flow is given by equation (1) by replacing D by $4R_h$ where R_h is the hydraulic radius (flow cross-sectional area divided by the wetted perimeter).

9.1.3 The Manning equation

For both circular and non-circular cross-sections whether running full or partially full, the velocity of flow is given by the equation:

$$v = KR_h^{\frac{2}{3}} J_E^{\frac{1}{2}} \tag{2}$$

where:
- K is the Manning coefficient, in metres raised to the power one third per second;
- R_h is the hydraulic radius, in metres;
- J_E is the hydraulic gradient (energy loss per unit length), dimensionless;

9.2 Headlosses

9.2.1 Pipeline headlosses

The hydraulic pipeline roughness (k) allows for headlosses due to pipe material, discontinuities at the joints and slime growth on the pipe surface below the water level.

9.2.2 Local headlosses

Headlosses, in addition to those mentioned in 9.2.1, occur at junctions, changes of cross-section, manholes, bends and other fittings. If direct calculations are to be made, the following equation shall be used:

$$h_L = \frac{k_L v^2}{2g} \tag{3}$$

where: h_L is the local headloss, in metres;
k_L is the headloss coefficient dimensionless;
v is the velocity of the liquid, in metres per second;
g is the gravitational constant, in metres per second squared.

9.2.3 Total headlosses

Two methods of calculating total headlosses are:

- adding local headlosses (9.2.2) to the pipeline headlosses (9.2.1);

- accounting for local headlosses by assuming a higher value of hydraulic pipeline roughness in the calculation of pipeline headloss.

When using recommended hydraulic pipeline roughness values it is necessary to establish whether allowance has been included for local headlosses. Values currently in use range from 0,03 mm to 3,0 mm for k and 70 $m^{1/3}s^{-1}$ to 90 $m^{1/3}s^{-1}$ for K. More detailed advice is given in the documents referred to in clause 4 and listed in annex A.

In cases where deposits in the invert cannot be avoided, the reduced cross-section of the pipe shall be taken into account when calculating headlosses.

Approximate comparisons of velocity estimates using equations (1) and (2) above may be made using the following equation:

$$K = 4 \cdot \sqrt{g \cdot \left(\frac{32}{D}\right)^{\frac{1}{6}}} \cdot \log_{10}\left(\frac{3,7D}{k}\right) \qquad (4)$$

where: K is the Manning coefficient, in metres raised to the power of one third per second;
g is the gravitational constant, in metres per second squared;
D is the internal pipe diameter, in metres;
k is the hydraulic pipeline roughness, in metres.

9.3 Sewers with steep gradients

Where sewers with steep gradients are required, consideration shall be given to consequences of high velocities such as:

-possible air entrainment and its effects;

-possible release of hydrogen sulfide;

-possible erosion;

-the need for energy conservation measures on super-critical flow to sub-critical flow;

-special safety measures for operatives.

Backdrop manholes, ramp manholes or vortex manholes may be installed in a sewer system to dissipate excessive static head in a controlled manner, thereby avoiding the installation of sewers with steep gradients and meeting any imposed velocity limitation.

10 Wastewater design flows

10.1 Water consumption statistics

Existing water supply statistics may be helpful to derive future water supply consumption and hence wastewater flows. Flow patterns for daily consumption and anticipated variations between different types of development can also be established. Consumer water usage that does not enter the drain and sewer system and distribution leakage are of particular importance in assessing wastewater flows.

10.2 Sewer systems

Sewer systems shall be designed to convey wastewater discharges from domestic, commercial and industrial premises to the point of treatment without prejudice to health and safety. Such design should also include allowances for future growth and for extraneous discharges up to such flow that will justify rehabilitation.

For domestic wastewater sewers, flowrates are usually based on either population and a rate of flow per head or, for new developments where such data may not be available, on the planning criteria for the population or the type and number of dwellings. For a new development and for an upgrading scheme on an existing development, the estimates used shall be appropriate for the specified planning horizon.

The rate of flow per head may be based on local water supply statistics allowing for consumption that does not result in discharge to the sewers and, where appropriate meters are not available, distribution losses. Typical discharge figures for developments similar to those under consideration may also be used. The flow per head, in the range from 120 l/day to 400 l/day, commonly used in various countries is shown in table B.1 of annex B.

The peak design flow takes account of the diurnal variation in wastewater flow. The domestic peak design flow rates commonly used in various countries are shown in table B.2 of annex B. To these peak design flows shall be added commercial and industrial peak flows and, where appropriate, infiltration.

Where a scheme is to be developed in phases, consideration should be given to the likely flows following the initial stages of construction so that either self-cleansing velocities are attained at least at times of daily peak flow or other cleansing arrangements are made.

10.3 Drain systems

The design of drains (and sewers) to serve individual or small groups of buildings where discharges from individual appliances will give relatively high flows of an intermittent and irregular nature shall use a peak rate of flow derived from the number and type of appliances connected.

Flowrates from the drains within the serviced buildings or premises shall be used in the design of downstream drain systems. Preferably national standards transposing European standards, as available, should be used for calculation of flowrates.

Flowrates for individual appliances and factors to be applied may be specified by the relevant authority.

In the absence of such data, national standard, or European Standard the empirical approach described in annex C may be adopted.

Trade effluent flows shall be calculated separately.

Having completed the design of the drain system, the interaction between the drain and the sewer system shall be checked.

11 Surface water and combined drain and sewer design flows

11.1 General

Surface water and combined drains and sewers are designed to collect and convey runoff generated within a catchment area during rainfall, for safe discharge into a receiving water or treatment plant. The magnitude of peak flows depends on the intensity and duration of rainfall, the size and configuration of impermeable areas and measures taken to reduce surface water. The topography, soil type and its permeability have also to be considered when estimating the flows emanating from other areas.

11.2 Rainfall - performance criteria

It is normally impracticable to avoid flooding from very severe storms. A balance therefore has to be drawn between cost and the level of protection provided. Attention is drawn to the performance criteria for protection against surcharge and flooding, wherever specified by a relevant authority. For small schemes the "design storm frequency" for no surcharge criteria in table 1 should be used in the absence of any specified by a relevant authority.

Table 1: Recommended design frequencies

Design storm frequency* (1 in "n" years)	Location	Design flooding frequency (1 in "n" years)
1 in 1	Rural areas.	1 in 10
1 in 2	Residential areas.	1 in 20
	City centres/industrial/commercial areas:	
1 in 2	- with flooding check;	1 in 30
1 in 5	- without flooding check.	-
1 in 10	Underground railway/underpasses.	1 in 50
* For these design storms no surcharge shall occur		

For larger schemes, design should be undertaken to limit frequency of surcharge using a sewer flow simulation model following which the design should be checked to ensure that an adequate level of protection against flooding will be provided at specific sensitive locations. These design checks are particularly important on steeply sloping catchment areas. Any requirements from the relevant authority shall be followed. In the absence of specified design flooding frequency values those given in table 1 should be used.

11.3 Design flows

11.3.1 General

For separate systems, design flows for the surface water pipelines will be predominantly runoff. No allowance shall be made for any wastewater component other than that resulting from firefighting.

For combined and partially separate drains and sewers, the design flowrate is made up of runoff, which