BRITISH STANDARD

BS EN 1671 : 1997

Pressure sewerage systems outside buildings

The European Standard EN 1671 : 1997 has the status of a British Standard

ICS 13.060.30

BSi

National foreword

This British Standard is the English language version of EN 1671 : 1997.

The UK participation in its preparation was entrusted by Technical Committee B/505, Waste water engineering, to Subcommittee B/505/23, Vacuum and other special drainage systems, 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 subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement these international or European publications 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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Pressure sewerage systems outside buildings

Réseaux d'assainissement sous pression à l'extérieur des bâtiments

Druckentwässerungssysteme außerhalb von Gebäuden

This European Standard was approved by CEN on 1997-04-11. 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 Central Secretariat or to any CEN member.

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CEN

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 165, Waste water engineering, through WG 23, Positive and negative pressure systems, and Tg 2, Pressure sewerage systems, 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of an identical text or by endorsement, at the latest by December 1997, and conflicting national standards shall be withdrawn at the latest by December 1997.

There are four 'informative' annexes; annex A gives some useful information additional to this standard, annex B has the figures, annex C contains the bibliography and national regulations, and annex D contains A-deviations.

In drafting this European Standard account has been taken of other available draft Standards.

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.

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Introduction

This European Standard covers positive pressure sewerage systems (PSS) and has been prepared for use by the designer, manufacturers, consultants, customers and operators.

A PSS is designed to transport domestic wastewater arising from dwellings and commercial properties and shall not be used for the disposal of stormwater or rainwater. The PSS comprises a single pressure pipe or a branched network of pressure pipes. The pressure generating equipment is always located at the upstream end of the pressure pipe(s). The downstream boundary of the system is defined as the point at which the total flow from the system discharges from a single pipe at atmospheric pressure into a recipient e.g. manhole, gravity sewer or sump.

The use of compressed air as the only means of generating pressure is not covered in this standard.

This standard covers the control of flow to the pumping main by random operation of pumps using i.e. level control and use of logic real-time control to manage pump output. However, the annex A is mainly concerned with random operations.

The use of small bore pressure pipes in conjunction with PSS may result in reduced environmental impact and consequential reduction in site construction leading to lower installation costs.

1 Scope

1.1 General

This European Standard specifies the performance, design, operation, maintenance and installation with related verification and test method for positive pressure driven sewerage systems outside buildings carrying wastewater.

It does not provide for the evaluation of conformity of systems to this European Standard. It does not specify the detail design or materials of construction of individual components within the system.

This European Standard covers positive pressure sewerage systems designed for transporting wastewater, defined as: Domestic sewage arising from dwellings and commercial properties but excluding stormwater and rainwater.

This European Standard covers the design of a PSS and some requirements of products used together with the PSS in order to ensure the performance of a PSS.

The components of the system and in conjunction with the system should be evaluated by reference to the appropriate product standard. In the absence of a product standard, this standard may be used as a reference for drawing up a specification for that product.

1.2 Limit of design

Intermediate pressure booster equipment is not covered in this standard.

The use of compressed air as the only means of generating pressure is not covered in this standard.

The design requirements of this standard are minimum requirements and do not constitute in themselves a comprehensive design sufficient to ensure a correctly functioning system. Every system must be individually designed. Where proprietary components are employed, account should be taken of the advice of the component supplier.

1.3 Application of pressure sewerage systems (PSS)

Information on the use of pressure sewerage systems is given in **A.1**.

1.4 Sources of additional information

Documents which, whilst relating to specific systems, contain details which can be used within the framework of this standard are listed in informative annex C.

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.

prEN 476 *General requirements for components used in discharge pipes, drains and sewers for gravity systems*

prEN 805 *Water supply — Requirements for external systems and components*

EN 60204-1 *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1 collecting chamber

Chamber into which the wastewater flows by gravity. This chamber may take the form of either a collecting tank or a collecting sump.

3.2 pressure generating equipment

Pump(s) installed at the collecting chamber which provides the pressure for transporting the wastewater within the pipe system. Compressed air systems may be connected at strategic points for the purpose of airflushing the pipe system.

3.3 Pressure sewerage system (PSS)

The PSS is a system for transporting domestic wastewater comprising a single pressure pipe or a branched network of pressure pipes where the pressure generating equipment is always located at the upstream end of the pressure pipe(s). The disposal point is the point the total flow from a pressure system discharges at atmospheric pressure, e.g. a manhole, gravity sewer or sump.

4 System description

4.1 General

A PSS consists of collecting chambers, pressure generating equipment and pipes forming a branched network.

4.2 Main components

The pressure sewerage system consists of the following main components:

- the collecting chamber (**4.3**);
- the pressure generating equipment (**4.4**);
- pump unit (**4.4.1**);
- compressed air unit, if required (**4.4.2**);
- pipework (**4.5**);
- pipe-joints (**4.5.2**);
- valves (**4.5.3**).

Figure B.1 shows an example of a pressure sewerage system.

4.3 Collecting chamber

The collecting chamber may serve one or more buildings. The maximum number of buildings will be dictated by the capacity of the pressure generating equipment.

Liability arising from the operation and maintenance of the collecting chamber, or local regulations, may dictate the use of separate collecting chambers for each dwelling or building.

The essential elements of a collecting chamber are:

- ventilation;
- a suitably rated electrical supply;
- controls and alarm equipment;
- level control sensors within the chamber for automatic control of the pumps;
- non-return valves and isolation valves to prevent back flow from the downstream system.

Construction materials shall be suitable for operation with sewage.

The working volume in the sump and the residual volume remaining at the end of the pumping sequence shall be designed to be as small as possible without adversely effecting the operation of the pump. (See also **4.2.**)

When designing and installing the chambers, due account should be taken of the risk of fracture of the pipework passing through the chamber wall, that may result from differential movement, vibrations etc.

The bottom of the chamber shall be designed to be self cleansing to minimize the risk of sedimentation, and operate with small working volume to minimize the retention time, an example of which is given in figures B.2 and B.4.

All collecting chambers shall be designed to resist external forces. The collecting chamber shall be watertight and shall not leak. Access frames and covers shall prevent the ingress of surface water.

National or local regulations may allow use of collecting chambers inside buildings.

Where indoor collecting tanks are used, an example of which is given in annex B, figure B.3, they shall incorporate a gas tight cover and be installed and insulated to prevent the transmission of noise and vibration to the property.

Consideration shall be given to the prevention of backflow when designing a system incorporating collection tanks.

The cover of a collecting sump is not necessarily gas tight. Within the collecting sump the pump(s) are installed together with associated level control sensors, pipework and valves. Figure B.2 illustrates an example of a typical collecting sump.

See also **A.2.1**.

4.4 Pressure generating equipment

4.4.1 *Pump units*

Examples of pumps used in pressure sewerage systems are:

- multivane open impeller pumps with grinding device;
- semi-positive displacement pumps with grinding device;
- single vane non-clogging centrifugal pumps;
- vortex pumps.

The most commonly used pumps in a PSS are submersible pumps, with or without grinding devices.

The pumps are mounted inside the collecting sump (see collecting chamber, **4.3**), with one or two pumps per sump.

NOTE. Pump(s) is/are generally mounted externally to collecting tanks (see figure B.3).

For the effective function of a PSS 'standard execution motors' are normally used. However, national or local regulations can demand explosion-proof certified motors and level control equipment. For further information see EN 60204-1.

Air locks in the pumps shall be avoided.

See also **A.2.2**.

4.4.2 *Air compressor units*

Compressed air may be used to support the flow of wastewater.

Where compressed air is required the compressed air station (static or mobile) should be located (or connected) upstream of the branch that needs support.

The compressed air stations can be equipped with air compressors, compressed air reservoirs and compressed air release controls, or compressors which work directly on the pressure pipe without pressure reservoir.

See also **A.2.3**.

4.5 Pipework

4.5.1 *General*

The pipes form a branched network or pipeline tract.

The pipelines, in general, are laid to follow ground contour. High and low points can be arranged as desired.

Air bleeding devices (air release and/or air inlet valves or vent stack pipes), suitable for sewage applications, might be necessary at high points. All high points shall be clearly identified. Note though that odours and waterhammer might occur, which shall be checked in the planning stage.

The whole pressure pipeline shall be constructed from corrosion resistant materials unaffected by permanent contact with wastewater, wastewater gases and surrounding ground conditions. The pipes shall have a smooth interior and be resistant to cyclic stresses.

The pressure pipelines in a collecting chamber and in the pipe-system shall be constructed to a minimum pressure rating of 600 kPa (6 bar). Account should be taken of any long term loss of strength of the pipe material, e.g. where pipelines are installed above ground or are likely to be subject to hot effluent. See also prEN 476.

Unused connections are to be sealed against the internal pressure and to prevent the ingress of ground water.

Joints and their components shall comply with the relevant European Product Standard and be installed in accordance with the manufacturer's instructions. Until the European Standard and unified regulations are available, standards and regulations at the place where the system is being constructed shall apply.

4.5.2 *Pipe-joints*

The pipe jointing system shall present a smooth unobstructed interior surface in order to avoid sedimentation and blockages.

4.5.3 *Valves*

Isolation valves shall be provided to help facilitate maintenance, locate leakage and permit repairs, i.e. on each branch.

5 Requirements

5.1 General

The PSS shall transport the sewage from the collecting chamber(s) to the outlet under all normal operating conditions.

All PSS's shall be designed to comply with national and local regulations. In addition, the PSS shall satisfy the following requirements.

5.2 Essential requirements

The essential requirements of a PSS are that:

- there shall be no danger to public health;
- there shall be no danger to operating personnel;
- the required design life and structural integrity shall be ensured.

5.3 Performance requirements

The performance requirements of a PSS are that:

- the system shall operate without blockages;
- flooding shall be eliminated or limited to identifiable circumstances and frequencies prescribed by national or local authorities;
- surcharge of incoming gravity sewers should be eliminated or limited to identifiable circumstances and frequencies;
- they shall not endanger existing adjacent structures and services;
- pipes shall be pressure-tested in accordance with performance specifications;
- odour or other nuisance shall not be generated;
- access for maintenance shall be ensured.

In the event of power failure pressure generating equipment shall automatically restart on the re-establishing of the power supply.

An acoustic and/or visual high level warning system shall be provided to indicate operational failure.

The system shall fulfil the following design criteria, i.e. minimum velocity (see **5.4.2**) and retention time of the wastewater in the pipes (see **5.4.3**).

5.4 Design requirements

5.4.1 *Pipes*

The pressure pipes shall have a bore equal to or exceeding the outlet bore of the pump. There shall be no decrease in the bore in the direction of flow (see **4.4** and **7**).

Siphon effect in the pipe system that could result in clogging in the collecting chamber and/or pump shall be considered.

National or local regulations may dictate the minimum bore of pipe that can be used in a PSS. This minimum bore may be influenced by the type of pressure generating equipment selected.

5.4.2 *Minimum velocities*

In order to reduce the possibility of sedimentation and settling out of solids a minimum velocity of 0,7 m/s shall be achieved at least once in every 24 h. Velocities below 0,7 m/s may be acceptable during certain operating conditions provided that the criterion above is satisfied.

When pumps are incapable of achieving the conditions given above consideration shall be given to the incorporation of a compressed air system for periodic flushing of the system.

See also **A.3**.

5.4.3 *Maximum retention time*

In order to limit gas formation within the system, wastewater should not be retained for longer than 8 h. This time may vary depending on national and local regulations and local circumstances.

5.4.4 *Emergency conditions*

The emergency storage volume, e.g. at power failures, can be provided by the collecting chamber itself and possibly the appropriate gravity pipe line(s). The emergency storage volume shall be equal to at least 25% of the total mean daily inflow, to be contained above the normal start water level.

If the emergency storage volume is not sufficient, special safety measures shall be taken.

5.4.5 *Power supply*

Adequate power supply for the complete system is to be agreed upon in the planning stage.

Due care shall be taken to ensure that the electric supply is not overloaded when restarting, e.g. after power failure.

5.5 Calculation requirements

When designing the pipe system, i.e. calculating the pipe diameters, the design-pipe-flow shall be calculated in order to fulfil the design requirements (see **5.4**).

6 Design and calculation of pressure sewerage systems

6.1 Principles

The designer shall take into consideration any known possible future additions or modifications to the system to avoid operating problems.

The sizing of pipes in the system is dependent upon the flow through the pipes and the distance to be transported. The flow is dependent on the capacity and frequency of operation of each pump, the number that are running simultaneously, and upon the inflow into each sump.

Methods of calculation are referenced in annex C.

See also **A.4.1**.

6.2 Gas formation in sumps and pipes

Retention times in collecting chambers and pipes shall be kept to a minimum in order to reduce gas formation.

However, where this is not possible, consideration should be given to the use of proprietary systems for protection of the environment against odours and corrosion.

See also **A.4.2**.

6.3 System calculation

6.3.1 *General*

To achieve a fixed velocity of flow within a pipe at given static pressure difference ($h_{st,}$ [m]), a pressure (h_{tot} [m]) from a pump is required between the beginning and ending of the pipe.

$$h_{tot} = h_{st} + h_l \qquad [m] \qquad (1)$$

where h_l ([m]) is the head loss, which is divided into two parts, head loss due to friction losses (h_{fl}) and head loss due to point losses (h_{pl} [m]).

$$h_l = h_{fl} + h_{pl} \qquad [m] \qquad (2)$$

or

$$h_l = \frac{\lambda \times 1}{d} \times \frac{v^2}{2 \times g} + \xi \times \frac{v^2}{2 \times g} \qquad [m] \qquad (3)$$

where:

λ	[-]	is the friction value and is calculated with the use of Colebrook-White's formula and is dependent upon the Reynolds number and the roughness in the pipe;
d	[m]	is the internal diameter of pipe (bore);
g	[m/s²]	is the acceleration due to gravity;
l	[m]	is the length of the pipeline;
v	[m/s]	is the velocity of water;
ξ	[-]	is the point loss factor (minor (pipe) loss factor) in the pipeline.

When calculating the h_{tot} for different flows and presenting the result in a flow-head diagram the curve developed is usually called the system curve.

See also **A.4.3.1**.

6.3.2 *Duty point in filled pipes*

The intersection between the system curve (equation 1) and the performance curve of the chosen pump is the duty point for that pump in the system, where the flow shall be used to calculate the velocities in the pipes (see **5.4.2**).

6.3.3 *Duty point in partly filled pipes*

Air pockets may develop down-stream of a high point in the pipeline. This will increase losses and shall be considered during the system calculation in order to avoid low velocities in the pipes (see **5.4.2**).

See also **A.4.3.2**.

6.3.4 *Transients (waterhammer)*

The design of the system shall take account of possible transients and waterhammer.

6.4 Pipe sizing

Utilizing the principles of **6.1** and the stipulated minimum velocity allowed (see **5.4.2**) the optimum bore diameter of the pipes shall be calculated. The optimum bore diameters are then modified to bores available in the chosen pipe material. In selecting from available pipe bores it shall be ensured that the minimum velocity (0,7 m/s) is maintained. Then the total head (h_{tot}) is calculated with use of the modified bore diameters and the flow. With the knowledge of the flow and the total head (h_{tot}) a suitable pump can be chosen. After that a system calculation with use of the performance curve of the pump should be done in order to make sure that the design criteria are still fulfilled, i.e. design flow of pump and minimum velocity.

There is no need to design the system when all pumps are running, as this will only occur after power failure and is therefore not a common running sequence.

7 Installation (pipe-laying)

Pipe-laying should be in accordance with prEN 805.

Pipelines shall be protected from freezing in accordance with local requirements.

Bends/junctions/valves shall be stabilized appropriately.

Sharp changes in direction shall be avoided as far as is practicable in order to prevent blockages developing.

Consideration should also be given to forces in the pipeline when empty and precautions taken against possible flotation.

Where pipe joints occur they shall be appropriate for the type of pipe selected.

See also **A.5**.

8 Quality control

An effective documented quality control system shall be established so as to achieve compliance with product standards.

The basis and the calculations of the system design shall be provided on request to the customer or end user.

NOTE. Specialised and qualified personnel, capable of assuring the quality of the work within the meaning of this standard, should be employed for the supervision and execution of the construction.

Construction work shall be executed in accordance with prEN 805.

9 Test methods

The pipe system shall be tested to prove it is pressure tight, in accordance with prEN 805.

By measuring the pressure head at the pressure equipment (in the collecting chamber), the flow can be found from the performance curve of the pressure equipment, and thereby the velocity in the pipes can be calculated or use of other suitable method. The measurement shall confirm the minimum velocity according to **5.4.2**. Connection for pressure measuring equipment should be provided.

Installed warning systems shall be checked for their function.

10 Commissioning, operation and maintenance

10.1 General

All gravity drains shall be clear of building material and debris before the collecting chambers to which they discharge are commissioned and any illicit surface water connections should be diverted. All collection chambers shall be cleaned and contain no foreign matter. The cleaning shall be completed before any commissioning tests are undertaken.

As constructed drawings of the system and an operator's manual shall be provided.

The manufacturer shall advise of any special tools and equipment needed to operate and maintain the system and recommend an appropriate holding of spare parts.

The manufacturer shall make available facilities for operator training. The training shall cover installation, operation and maintenance and record keeping and interpretation.

The contractor shall demonstrate that all the equipment functions satisfactorily.

Servicing of the pump and the compressor stations shall be based upon the manufacturer's instructions and/or national prescriptions. It is recommended that the sumps, including pump(s) and when available compressor(s), are inspected annually. Operating experience of each installation may indicate the need for a different frequency of inspections.

A maintenance programme shall be established and fault rectification service shall be instituted by the suitable qualified operator.

NOTE. It is good practice to install an operating hour counter to monitor delivery equipment running hours.

10.2 Statutory considerations

An agreement will normally be required to carry out maintenance and servicing on those parts of the system on private property.

See also **A.6.1**.

10.3 Cleaning of the pipes

Flushing connections should be made upstream of each branch so that each branch can be flushed if needed.

Cleaning of the pipes is usually unnecessary, however, when required there are several ways of cleaning the pipes such as flushing with air or water.

No cross-connection shall be made between drinking water systems and pressure sewerage systems.

Note though that frequent flushing with water is not allowed in some countries.

See also **A.6.2** and **A.4.2**.

Annex A (informative)
Additional information

A.1 Application of pressure sewerage systems

This is additional information to **1.3**.

While densely populated areas can be relatively cheaply drained, a gravity wastewater removal system may be uneconomic in less densely populated areas due to the high costs of gravity sewerage systems. Therefore consideration should be given to a pressure system.

Pressure sewerage systems differ from the conventional gravity systems in that, in place of the wastewater system with numerous manholes, closed pipelines without entry facilities are used. Gravity systems run downhill. Pressure follows contours/uphill.

Pressure sewerage systems are an alternative to gravity sewerage systems and vacuum sewerage systems.

Consideration should be given to PSS where one or more of the following apply:

- insufficient terrain gradient;
- high ground water levels;
- low population density;
- adverse sub-surface conditions;
- when wastewater occurs intermittently (e.g. at camping sites);
- when the environmental considerations are critical;
- large scale carriageway repair costs or similar are involved;
- where there is a proliferation of existing utility services.

In considering these cases, particular attention should be paid to the financial aspects and to the permanent operating costs. The PSS allows maximum freedom in overall design regardless of topographical conditions. The economic optimum should be researched. In certain cases it is obtained by combining gravity links together with areas covered by pressure pipework networks.

A.2 System description

A.2.1 *Collecting chamber*

This is additional information to **4.3**.

The build up of sedimentation in the collecting chamber can be reduced by having benching to direct the debris toward the pump entry, thus ensuring it is pumped away, alternatively the same result may be achieved hydraulically.

The operation of the pressure equipment is controlled using equipment which monitors the water level, e.g. through compressed air bubbling, floats, pressure probes (automatic on-off switching and high level alarm), etc.

Correct closure of non-return valves, especially ball valves, can be assisted by a counter pressure of some 2 m of static head or through a vertical positioning of the non-return valve.

A.2.2 *Pump units*

This is additional information to **4.4.1**.

The changes in the characteristics of wastewater reaching the sewage treatment plant caused by pumps with grinding devices usually do not have to be considered. Pump grinding devices should not be confused with waste macerators, which are able to grind all biological waste from a household.

A.2.3 *Air compressor units*

This is additional information to **4.4.2**.

The compressed air stations are usually situated in small, single storey, ground level buildings. They can also be installed underground or in free-standing waterproof kiosks. Compressed air creates noise and it is therefore recommended that sound protection measures are taken and a sufficient separation from surrounding buildings is maintained.

When dimensioning the compressor station, account should be taken of the fact that considerable pressure losses can occur between compressor and pressure pipelines. The calculated pressure should be available directly at the point of air input to the pressure tank.

For safe operation the room temperature should be between +1° C and +35 °C, although the upper value can be exceeded briefly. This necessitates appropriate insulation and ventilation.

The necessary meters, such as operating hour counters for the compressors, and other monitors should be provided. For compressed air reservoirs the relevant safety regulations regarding manufacture, installation, acceptance testing, monitoring and operation, should be observed.

A.3 Minimum velocities

This is additional information to **5.4.2**.

The term 'self cleansing velocity' refers to the flow velocity required to convey solids along with the water carrier. Therefore to maintain an unobstructed pipeline, the flow velocity should be sufficient to transport grit and solids that may be present in the wastewater, to prevent grease depositing on the crown of the pipe, and to scour and resuspend previously settled matter.

When pressure mains are used to convey conventional wastewater or when a grinder pump pressure sewer is used, the normally agreed self cleansing velocity is usually taken as about 0,6 to 0,9 m/s. That velocity should occur once or twice daily. The higher velocity of 0,9 m/s is preferred with regard to scouring, but the higher flow rates correspond with higher headloss and the need for higher head pumps [6].

A.4 Design and calculation of pressure sewerage systems

A.4.1 *Principles*

This is additional information to **6.1**.

In [8] there are two methods of calculating the pipe-design-flow presented:

- Statistical method
- Peak flow method.

A.4.2 *Gas formation in sumps and pipes*

This is additional information to **6.2**.

Wastewater transportation installations which rely upon normal operation conditions with regard to retention time and ventilation can encourage the formation of hydrogen sulfide (H_2S) by anaerobic paths. If such preloaded wastewater is fed into a free surface sewer there is a danger of the creation of biogenic sulfuric acid corrosion in sewers. Wastewater is subject to a natural decomposition process. The formation of H_2S occurs by anaerobic paths in the biofilm clinging to the inside of pipes and in the sludge deposited at certain points in the pipe system if the velocity is too low. Retention time, velocities in the pipes, temperature, redox potential and percentage of oxygen dissolved are the main parameters.

The release of the H_2S gas generally takes place at the end of the pressure pipe when atmospheric pressure applies. The gas combining with condensation on the walls of the gravity sewer produces sulfuric acid. Corrosion can take place on material not offering adequate resistance.

In extreme cases, for example areas with high seasonal variation of population, preventative action should be taken, such as flushing sections or the whole network with either water or compressed air – the latter being selected more often as the flushing agent (see **10.3**).

A.4.3 *System calculation*

A.4.3.1 *General*

This is additional information to **6.3.1**.

The general equation for a system curve is:

$$h_{tot} = \sum_{i=1}^{n} \left\{ h_{st\,i} + \left(\xi_i + \frac{\lambda_i x l_i}{d_i}\right) \times \frac{v_i^2}{2 \times g} \right\} \quad [m] \qquad (A.1)$$

where:

d_i	[m]	:	internal diameter of pipe number i
g	[m/s^2]	:	acceleration due to gravity
$h_{st\,i}$	[m]	:	static (geodetic) pressure head of pipeline number i
h_{tot}	[m]	:	total pressure head
l_i	[m]	:	length of the pipeline number i
v_i	[m/s]	:	velocity of water in pipeline number i
ξ_i	[-]	:	point loss factor (minor (pipe) loss factor) in pipeline number i
λ_i	[-]	:	friction value in pipeline number i

Variable factors regarding the layout, such as quality of installation and operation conditions effect the final result. Due to sedimentation caused by insufficient velocity of flow, the friction element of head can change during the course of time and under certain circumstances the pipe diameter might become smaller (unusual for a well designed pressure sewerage system). Furthermore, the chemical and solids content of the wastewater is to be thought of as rather variable and uncertain. In addition to this, problems related to air entrapment in the pipe system are to be considered as these can increase the friction characteristics and make flushing by compressed air unsuitable under certain circumstances.

The roughness in the pipe is usually specified by the manufacturer for new pipes. The roughness, however, changes by time and after some years of usage the variation can be between 0,1 and 1,0 mm.

A.4.3.2 *Duty point in partly filled pipes*

This is additional information to **6.3.3**.

The hydraulic design should take into consideration the fact that airpockets can develop within declined pipes, which increase the losses.

A.5 Installation (pipe-laying)

This is additional information to **7**.

All pipes can be laid in the same trench or duct but strictly in accordance with local regulations. Each pipe should have a special marking in order to prevent confusion. If needed, a heating element wire, insulation and/or insulation duct can be provided to prevent freezing.

In certain circumstances it may be necessary to provide a dual pipe system where high seasonal flows are experienced, e.g. camping sites.

A.6 Operation and maintenance

A.6.1 *Statutory questions*

This is additional information to **10.2**.

The following statement in the drainage statutes is possible:

'If wastewater from private property is fed into a pressure sewerage system the owner is to allow the establishment, on his property, of the facilities which serve to collect and transport the wastewater as well as the connection pipelines between these facilities and the boundary of the property. The same applies for the operation and maintenance as well as for the necessary repair, modification and renewal work. Type and location of the facilities are determined by the responsible agency. Pipelines and sumps may not be built upon. Defects in the facilities for collection and transportation of the wastewater which are noted by the owner of the property or another user are to be reported to the responsible agency. The owner is to allow the employees of the responsible agency and those authorized by it access to the facilities and pipelines.'

A.6.2 *Flushing*

This is additional information to **10.3**.

The flushing of the pipes can be by means of either water or air.

The intention of flushing is not as a method of transportation of the wastewater (see **4.3**) but to take care of:

- systems that for some reason are not able to maintain minimum velocity for self cleansing (**5.4.2**) or maximum retention time (**5.4.3**);
- systems with uneven distribution of wastewater generation (e.g. camping areas).

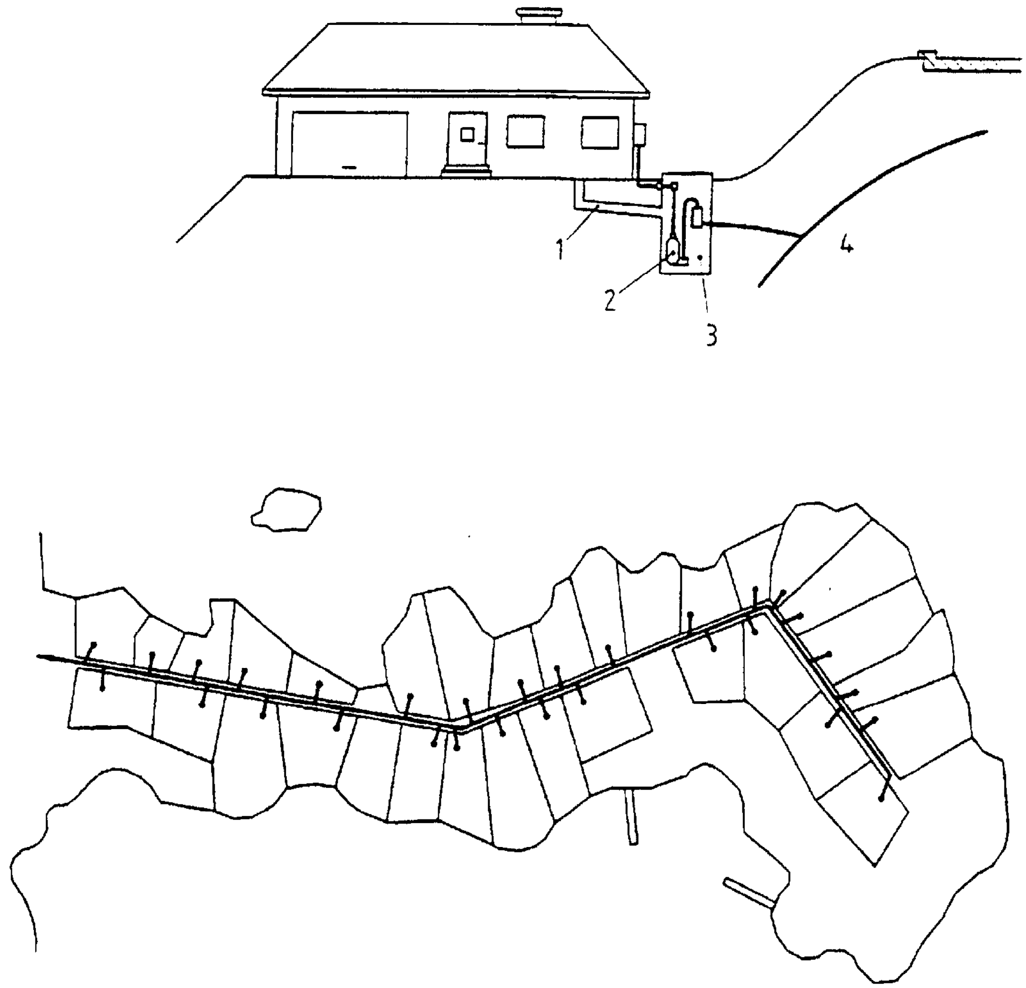
The flushing regulates and supports the flow process within the pressure pipe system in that it inputs air or water into the system with the following effects:

- shortening the retention (dwell) time of the wastewater;
- minimizing the formation of H_2S;
- loosening deposits and encrustation using high flushing velocities.

Flushing connections should be installed to maximize the flushing effect on the pipeline system.

If a permanent flushing station is used, a failure of one flushing station for several hours or even for a few days does not immediately lead to a significant prejudicing of the operation of the drainage system, and therefore a warning system and emergency power supply are not required.

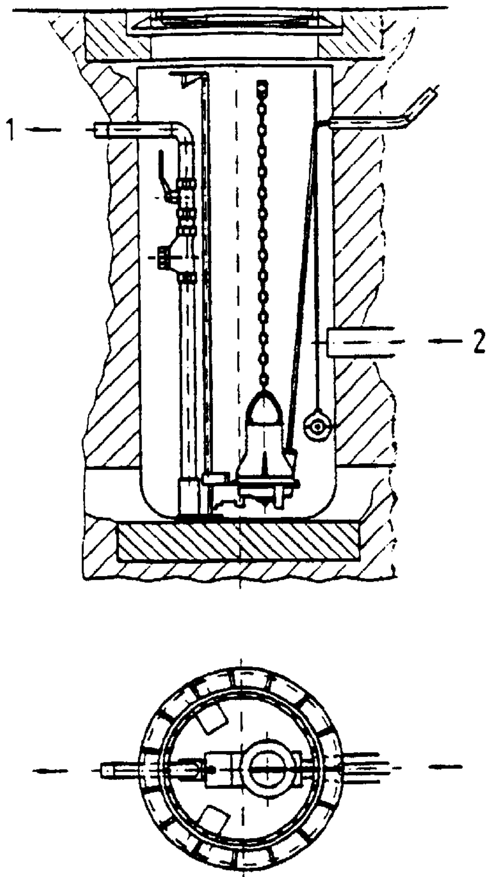
Annex B (informative)
Figures



1 Gravity drainage pipe
2 Pump
3 Collecting chamber
4 Pipe system

Figure B.1 Example of a PSS with the collecting chamber, pump and pipe system

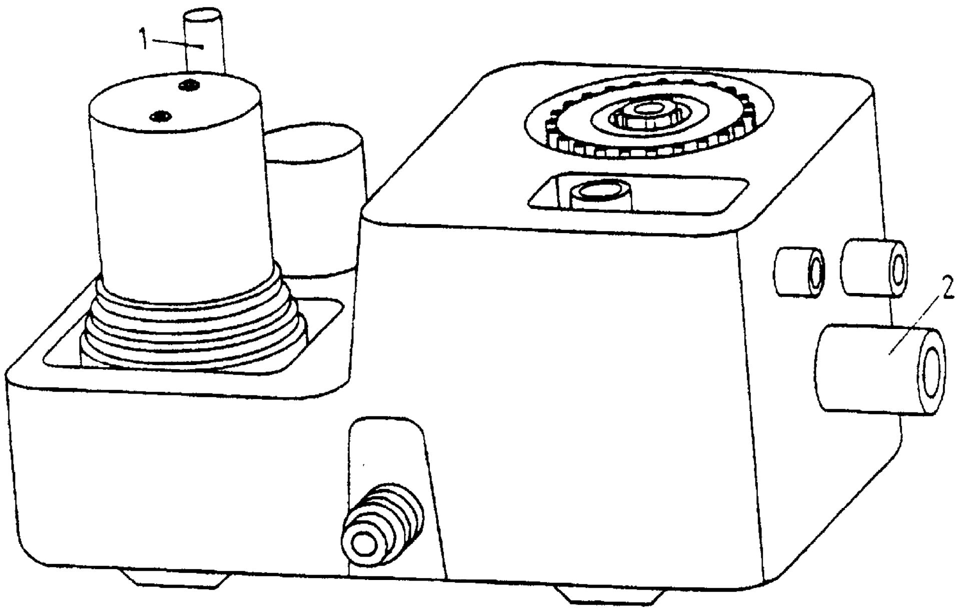
Above figure includes a plan view of a PSS. This figure is additional information to **4.2**.



1 Pumped outflow
2 Gravity inflow

Figure B.2 Typical example of fibre-glass/reinforced polyester collecting sump

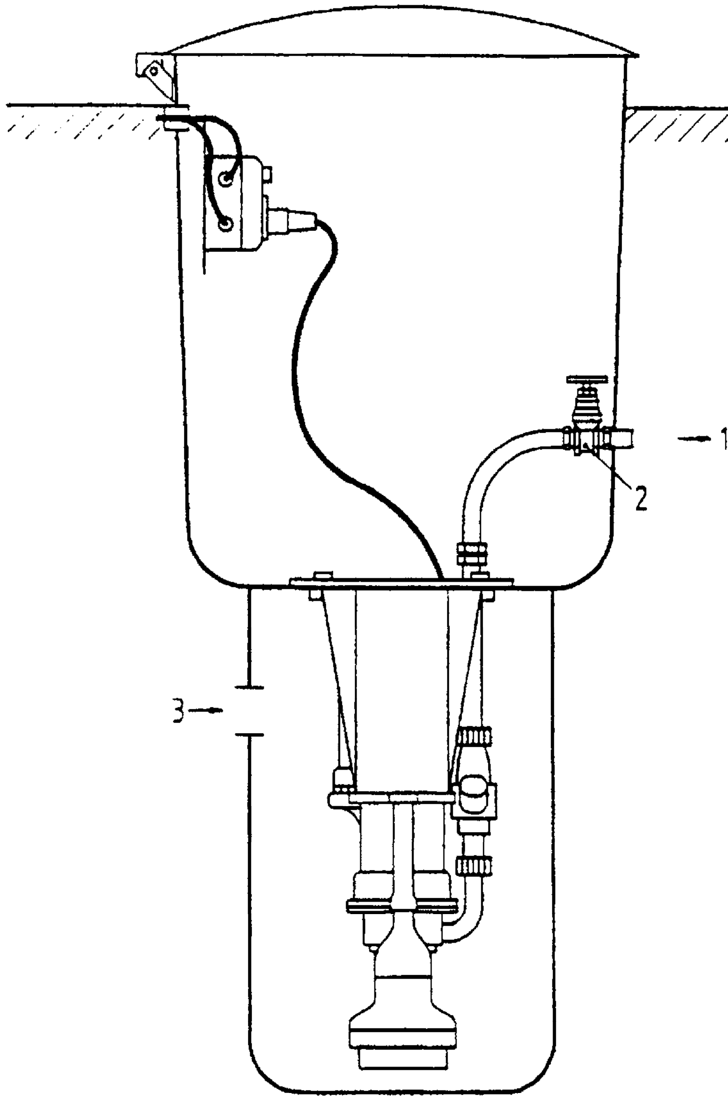
This figure is additional information to **4.3**.



1 Pumped outflow
2 Gravity inflow

Figure B.3 Example of a collecting tank with pump

This figure is additional information to **4.3** and **4.4.1**.



1 Pumped outflow
2 Isolating valve
3 Gravity inflow

Figure B.4 Example of a collecting sump with pump and prefabricated manhole

This figure is additional information to **4.3**.

Annex C (informative)

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(An English pre-issue of this paper from Jan 1991 was used when creating this standard: *Special Drainage Systems: Vacuum Drainage — Pressure Drainage*)

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Annex D (informative)

A-Deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

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DENMARK

Arbejdstilsynets bekendtgørelse nr. 473 af 7. oktober 1984, om kloakarbejde m. v.

Arbejdsministeriets bekendtgørelse nr. 1017 af 15. december 1993, om indretning af byggepladser og lignende arbejdssteder efter lov om arbejdsmiljø

Arbejdsministeriets bekendtgørelse nr. 867 af 13. oktober 1994 om arbejdets udførelse

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