Vacuum sewerage systems outside buildings

The European Standard EN 1091 : 1996 has the status of a British Standard

ICS 13.060.30

Committees responsible for this British Standard

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Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of EN 1091	3

National foreword

This British Standard has been prepared by Technical Committee B/505, and is the English language version of EN 1091 : 1996, *Vacuum sewerage systems outside buildings* published by the European Committee for Standardization (CEN).

The United Kingdom was an active participant in the drafting process and voted for the final draft.

This standard does not supersede any British Standard.

Cross-reference

Publication referred to	Corresponding British Standard
EN 752-2	BS EN 752 *Drain and sewer systems outside buildings* Part 2 : 1997 *Performance requirements*

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 28, an inside back cover and a back cover.

EUROPEAN STANDARD

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EN 1091

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ICS 13.060.30

Descriptors: Sanitation, water removal, sewage water pipelines, buildings, exterior, vacuum technology, performance evaluation, tests, design

English version

Vacuum sewerage systems outside buildings

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

Unterdruckentwässerungssysteme außerhalb von Gebäuden

This European Standard was approved by CEN on 1996-11-30. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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

CEN

European Committee for Standardization

Comité Européen de Normalisation

Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 1091 : 1996 E

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 European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 1997, and conflicting national standards shall be withdrawn at the latest by June 1997.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

		Page
Foreword		2
Introduction		3
1	Scope	3
2	Normative references	3
3	Definitions	3
4	Description of the system	4
4.1	Collection chamber and vacuum pipeline	4
4.2	Vacuum station	4
5	Requirements	4
5.1	General requirements	4
5.2	Performance and quantitative requirements	4
5.3	Design requirements	8
6	Installation	8
6.1	Installation	8
6.2	Tolerances	8
6.3	Warning and location system	8
7	Testing and verification	9
7.1	Testing of interface units	9
7.2	Testing of pipelines	9
7.3	Water tightness	9
7.4	Commissioning tests	9
8	Commissioning	9
Annexes		
A	(normative) Testing of interface unit	10
B	(normative) Testing of pipelines	11
C	(normative) Collection chambers: internal water pressure test	11
D	(normative) Commissioning tests	11
E	(informative) Typical configurations	12
F	(informative) Operational and maintenance information	26
G	(informative) Sources of additional information	27
H	(informative) Bibliography	27
I	(informative) Application of vacuum sewerage	27

Introduction

This European Standard has been prepared for specifiers, designers, constructors and operators of vacuum sewerage systems. This European Standard covers vacuum sewerage systems transporting domestic sewage but not rainwater.

1 Scope

This European Standard specifies the performance requirements of negative pressure driven sewerage systems carrying domestic waste water independent of their material. It also covers additional performance characteristics that are of importance to the specifiers, designers, constructors and operators of vacuum sewerage systems.

It does not provide for the evaluation of conformity of systems.

This European Standard gives guidance on the design and construction of vacuum sewerage systems which convey domestic waste water but not rainwater. It does not deal with internal vacuum drainage systems. The components of 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 product specification.

The design requirements of this European Standard are minimum requirements and do not constitute in themselves a comprehensive design guide sufficient to ensure a correctly functioning system. Every system must be individually designed, based on the design parameters of the system employed; where proprietary systems are employed, account should be taken of the advice of the system suppliers.

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 752-2	*Drain and sewer systems outside buildings — Requirements*
prEN 805	*Water supply — Requirements for systems and components outside buildings*
prEN 1293	*General requirements for components used in pneumatically pressurised discharge pipes, drains and sewers*

3 Definitions

For the purpose of this standard the following definitions apply.

3.1 batch volume

Volume of the sump up to the level at which the level sensor activates the controller.

3.2 collection chamber

Collection sump and interface valve pit.

3.3 collection sump

Sump provided to store flows of domestic waste water until sufficient has been accumulated to activate the interface valve.

3.4 controller

Device which, when activated by the level sensor, opens the interface valve and, after the passage of sewage and air, closes the valve.

3.5 forwarding pumps

Devices, installed at the vacuum station to deliver the sewage from the vacuum system.

3.6 interface valve

Valve which admits the flow of sewage and air into the vacuum sewer via the service connection.

3.7 level sensor

Device which senses the presence of sewage in the collection sump and activates the valve controller when a batch volume has collected in the sump.

3.8 lift

Section of vacuum pipeline with an increase in invert level in the direction of flow.

3.9 pipeline profile

Vertical alignment of the vacuum pipeline.

3.10 service connection

Part of the vacuum pipeline which connects a single collection chamber to the vacuum sewer.

3.11 vacuum generator

Equipment installed at the vacuum station to generate a vacuum in the sewer.

3.12 vacuum pipeline

Pipeline under negative pressure.

3.13 vacuum recovery time

Time taken, after the operation of an interface valve, for the negative pressure at the valve to be restored to a value sufficient to operate the valve again.

3.14 vacuum sewer

Part of the vacuum pipeline into which the service connections feed.

3.15 vacuum station

Installation comprising the vacuum generators, vacuum vessel (or sewage sump), means of discharge and control equipment.

3.16 vacuum vessel

Negative pressure vessel connected to the vacuum generator and vacuum sewer.

3.17 water-logging

Accumulation of wastewater at low points which fills the cross section of the vacuum pipeline.

4 Description of the system

4.1 Collection chamber and vacuum pipeline

When the volume of domestic waste water draining into a collection chamber reaches a predetermined level in the sump the normally closed interface valve opens. The differential pressure between the vacuum sewer and atmosphere forces the waste water from the collection chamber into the sewer. After the sump is emptied the valve closes. Air is admitted simultaneously with, or after, the admittance of the waste water. The waste water is driven along the sewer until frictional and gravitational forces eventually bring it to rest in the lower section of the pipe profiles. The characteristics of the vacuum sewerage system ensure that peak discharges into the sewer are rapidly attenuated. The vacuum sewer discharges into the vacuum vessel or sewage sump at the vacuum station. The vacuum is maintained, by a vacuum generator, at a predetermined level. The waste water is generally pumped from the vacuum station by forwarding pumps.

4.2 Vacuum station

The vacuum station is similar to a conventional sewage lift station with the addition of vacuum generators and a closed vacuum vessel or sewage sump. Vacuum sewers discharge into the vacuum vessel which is held under vacuum if vacuum pumps are employed, or into a sewage sump if the vacuum is generated by an ejector pump. The level of the sewage in the vacuum vessel is monitored by a level controller which activates the forwarding pumps or discharge valves. If the sewage rises too high in the vessel then a high level sensor stops and locks out the vacuum pumps to prevent the flow of sewage into the vacuum pump. The vacuum in the vacuum vessel is maintained within the operational range by pressure switches.

5 Requirements

5.1 General requirements

The system shall convey domestic sewage from the household drainage system to the vacuum station and forward it downstream and meet the following performance requirements:

a) the interface valve and pipework shall operate without blocking;

b) flooding shall not occur or shall be limited to identifiable circumstances and prescribed frequencies;

c) surcharging of collection chambers and sewers shall be limited to identifiable circumstances and prescribed frequencies;

d) the system shall not endanger existing adjacent structures and services;

e) the system shall be water and air tight as tested;

f) odour, or other nuisance, shall not be generated;

g) provision shall be made for maintenance.

5.2 Performance and quantitative requirements

5.2.1 *Gravity drains*

New gravity drains discharging to collection chamber sumps shall be in accordance with EN 752-2. Where air inlet valves are installed on new gravity drains they shall be designed to suit the vacuum sewerage system.

5.2.2 *Flows from interceptor sewers and commercial developments*

Where vacuum pipelines are used to intercept sewerage systems or accept domestic sewage from commercial developments the design performance criteria including the peak flow shall be specified.

5.2.3 *Collection chambers*

NOTE. One or more properties may be connected to a collection chamber in accordance with local or national regulations.

The chamber shall resist external forces and internal water pressure. The chamber shall be watertight. Frames and/or covers shall prevent the ingress of surface water. Separate chambers shall be provided to serve properties at different elevations where there is a risk of sewage from one property flooding another property. Thermal conductivity calculations or recorded past performance shall demonstrate that the valve mechanism will function during the anticipated extremes of temperature.

5.2.4 *Collection sumps*

Collection sumps shall be watertight. Collection sumps serving domestic properties shall provide capacity to store a minimum of 25 % of average daily flow in the event of a power failure or similar emergency; account may be taken of the storage in the gravity system.

The sump shall be constructed of material which is corrosion resistant and unaffected by contact with sewage. The internal surface of the sump shall be smooth and the sump shall have benching to maintain self cleansing flows.

Where the interface valve is situated over the collection sump a working platform shall be provided if needed for health or safety reasons.

The sump shall be sufficiently vented to allow the intake of air without causing a noise nuisance and to ensure that the operation of the vacuum system does not unseal the water traps on the gravity drainage system.

NOTE. National or local regulations may require additional measures to prevent backflooding from sumps into houses. These measures may include the provision of an overflow from the sump to define a backflood level below which no sanitary apparatus may be fitted.

5.2.5 ***Interface valve***

The interface valve shall fail safe in the closed position and shall prevent backflows from the service connection to the collection sump.

The sewer vacuum shall ensure positive valve seating. When the valve is open the flow path shall not be obstructed by the valve mechanism. The valve shall evacuate at least the batch volume each time it cycles.

Valves installed in the sump shall be capable of operating when submerged provided that the breather pipe is not also submerged.

The fixing arrangements shall enable the interface valve and/or control system to be readily replaced in not more than 30 min.

5.2.6 ***Level sensor***

The valve shall be equipped with a sensor to determine the level of sewage in the collection sump; this sensor shall be designed to be fouling resistant. Level sensor pipes shall not be less than DN/ID 45.

5.2.7 ***Interface valve controller***

The controller shall open the valve only if there is a minimum partial vacuum of 15 kPa below atmospheric available and shall maintain the valve fully open until at least the batch volume has been evacuated. If the design provides for the introduction of air after the sewage has been evacuated the controller shall maintain the valve open for a further period. The controller shall be adjustable so that a range of air to sewage ratios can be obtained. Controllers installed in sumps shall be capable of operating when submerged.

5.2.8 ***Explosion proof***

The valve mechanism and controller shall be explosion proof if exposed to potentially explosive atmosphere. Until a European Standard is produced the standards in the country of installation shall be met.

NOTE. National and local regulations can prescribe explosive proof electrical equipment.

5.2.9 ***Life of membranes and seals***

The manufacturer shall on request state the operating life of valve membranes and other seals employed.

5.2.10 ***Vacuum pipeline components***

The vacuum pipeline components, including pipes, fittings, joints and sealing materials shall comply with prEN 1293.

NOTE. Sharp bends should be avoided.

5.2.11 ***Pipe size***

The suction pipe DN/ID shall not be greater than the DN/ID of the interface valve. The minimum diameter of service connections shall be DN/ID 50 and shall be greater than the DN/ID of the suction pipe.

Vacuum sewers shall have a minimum diameter of DN/ID 65 where national or local regulations control the discharge of gross solids to sewers. Vacuum sewers shall have a minimum diameter of DN/ID 80 where there are no such controls over the discharge of gross solids to sewers or where national or local regulations require larger diameters.

NOTE. The maximum lengths of service connections and vacuum sewers corresponding to a particular DN/ID may be specified.

5.2.12 ***Service connections***

Service connections shall initially fall away from the interface valve and shall connect into the top sector of the vacuum sewer contained within the angle of ± 60° about the vertical axis.

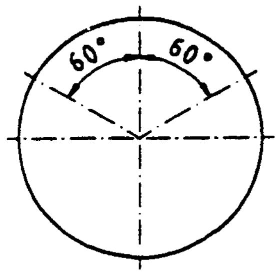


Figure 1. Service connection

5.2.13 ***Branch connections***

All branch connections to vacuum sewers shall be by a junction connected to the sewer above the horizontal axis. In plan, the angle of the junction shall ensure that flow towards the vacuum station is generated and backflows are minimised. No connection shall be made within 2 m of a lift.

5.2.14 ***Isolation measures***

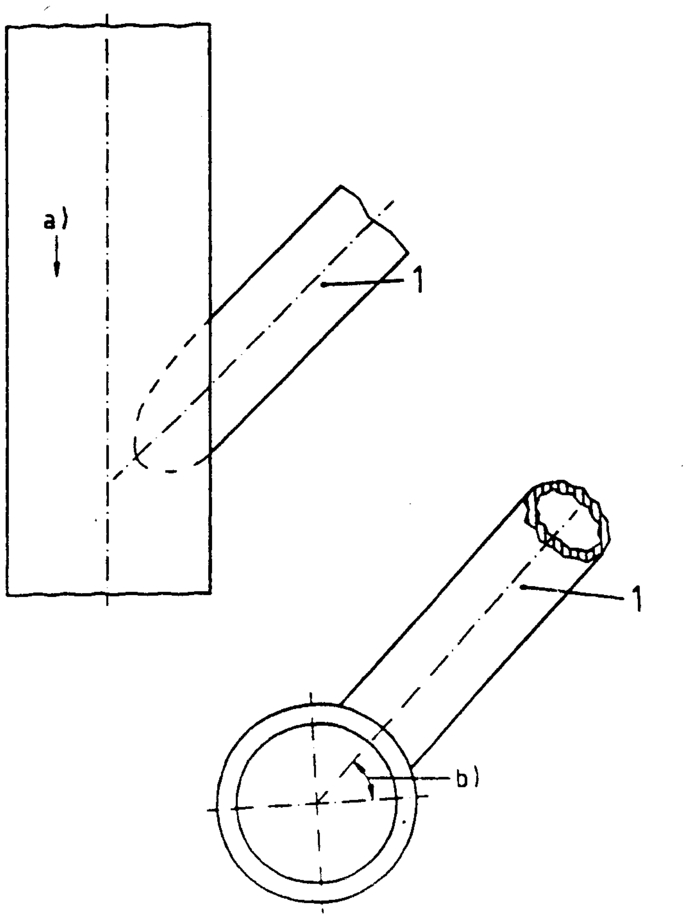
Means of isolating lengths of vacuum sewer to permit repairs or to locate faults shall be provided at distances of not more than 450 m and on branch sewers longer than 200 m.

Buried valves shall have extension spindles and surface boxes. The valve clear opening shall be not less than the DN/ID of the pipe.

NOTE. Isolation valves or other means of isolation such as inspection pipes which allow the introduction of inflatable balls may be employed. Isolation valves should be suitable for service in sewage under both vacuum and pressure should be capable of sustaining a differential vacuum of 80 kPa below atmospheric.

5.2.15 ***Vacuum vessel/sewage sump***

Each vessel shall be furnished with the required number of correctly sized sewage inlet and outlet pipes which shall be integral with the vessel. No inlet pipes shall be connected below the system emergency stop level. The inlet and outlet pipes shall be sited to encourage flow through the vessel and thus prevent the build up of solids. It shall be possible to inspect the vessel internally. Each vessel shall be furnished with access openings to allow for internal inspection and cleaning. Each vessel shall be fitted with a level control system which is suitable for operation in a vacuum and is easily removed for adjustment or replacement. When the sewage sump is used in conjunction with ejector pumps it shall have a minimum liquid capacity of 400 l per installed duty ejector.



1 branch
a) direction of flow
b) vertical angle

Figure 2. Branch

5.2.16 ***Vacuum station control***

The controls shall permit the selection of duty, duty assist (where provided) and standby vacuum generators and forwarding pumps and shall provide for the automatic introduction of the standby units in the event of failure. The vacuum generators shall be controlled by monitoring the vacuum in the vacuum vessel via adjustable pressure switches set to the desired operating range.

5.2.17 ***Level control***

The level control system shall respond to the following sewage levels in the vacuum vessel or the sewage sump:

Emergency stop level	– stops vacuum generation;
	– forwarding pump(s) operate;
Start level	– starts forwarding pump(s);
Normal stop level	– stops forwarding pump(s);

The following alarms with appropriate remote signalling shall be provided:

– low vacuum alarm, indicating that system vacuum is below the selected minimum pre-set level;

– high sewage alarm, indicating that sewage level in the vacuum vessel or sewage sump is at the high level mark;

– emergency alarm, indicating that a major piece of plant has failed or that the selected maximum continuous running time for the vacuum generator has been exceeded or that there is a power failure.

5.2.18 ***Equipment***

Vacuum generators (e.g. liquid ring or rotary vane pumps or ejector pumps) shall have sufficient capacity to serve the system. A minimum of two vacuum generators of equal capacity shall be installed such that one pump can be removed for maintenance without loss of system capacity.

NOTE. The type of vacuum generator and its minimum capacity and the type of discharge equipment and its minimum capacity may be specified. Vacuum pumps, where used, should be suitable for both continuous operation and for a minimum of 12 starts per hour.

5.2.19 ***Capacity of forwarding equipment***

Forwarding pumps or pressure vessels used to discharge the sewage shall have sufficient capacity to serve the system.

5.2.20 ***Design of forwarding pumps***

Forwarding pumps, where used, should be unchokable sewage pumps suitable for operating under negative pressure without cavitation. They shall be suitable for a minimum of 12 starts per hour. On systems serving more than twenty dwellings the design shall provide for pumps of equal capacity to be installed such that one pump can be removed for maintenance without loss of system capacity. Equalizing lines connecting the discharge side of the centrifugal forwarding pumps to the vacuum vessel shall be installed if required to prevent cavitation or to ensure that the pump inlet is always flooded.

5.2.21 ***Replacement of forwarding pumps***

Forwarding pumps installed outside the vacuum vessel shall be fitted with isolation valves to allow removal of the pump without disrupting the system operation. Where the discharge pipework is manifold the final discharge pipe shall also be fitted with an isolation valve. Where forwarding pumps are installed inside the vacuum vessel it shall be possible to remove and replace a pump in not more than 4 h. Where system shutdown for 4 h is not acceptable pumps shall be installed externally unless two vacuum vessels are employed and the system can be operated with one vessel out of action.

5.2.22 ***Explosive proof electrical equipment***

All electrical equipment operating in a potentially explosive atmosphere shall be explosive proof.

NOTE. National and local regulations can prescribe explosive proof electrical equipment.

5.2.23 ***Non-return valves***

Each discharge pipe from the vacuum vessel shall be fitted with non-return valves to prevent the black flow of sewage. Non-return valves shall also be fitted on the discharge pipework from each forwarding pump. Where the non-return valves, are installed inside the vacuum vessel it shall be possible to remove and replace them in not more than 4 h. Where the discharge pipework is manifold the final discharge pipe shall also be fitted with a non-return valve.

5.2.24 ***Ejector pumps***

Where ejector pumps are employed as vacuum generators, unchokable sewage pumps of equal capacity shall be installed such that one pump can be removed for maintenance without loss of system capacity. Isolation valves shall be fitted to permit the removal of the pumps without disrupting the system operation. Any foam produced shall be contained within the sump.

5.2.25 ***Odour control***

Where odour may cause a nuisance, odour control measures shall be employed.

5.2.26 ***Noise control***

The noise generated by the system shall not exceed that permitted by local or national regulations.

5.2.27 ***Emergency power generation***

The vacuum station shall have a standby power generator or a socket outlet into which a mobile power generator can be connected.

5.3 Design requirements

5.3.1 *Pipeline design*

Pipelines shall be designed to withstand the stresses arising from earth cover, traffic and cyclic loads, the range of negative pressures arising during operation and testing and flotation forces.

The minimum pressure rating for plastic pipes shall be 0,6 MPa but higher ratings shall be employed if the pipe has an initial ovality from coiling, or if long term loss of strength due to high temperature of the pipeline or sewage is likely to occur.

When pipelines are not buried, they shall be protected from extremes of temperature, ultra-violet radiation if necessary and mechanical damage.

5.3.2 *Pipeline profiles*

Pipeline profiles shall be self cleansing and prevent the accumulation of solids. For service connections the minimum distance between lifts shall be 1,5 m. Vacuum sewers shall have a minimum gradient of 1 in 500. Where the ground has a gradient of 1 in 500 or more in the direction of flow the vacuum sewer may be laid parallel to the surface. Where a downhill section is followed by an uphill section, the profile shall ameliorate water-logging at the change of gradient.

NOTE. To provide for efficient vacuum transport the size of individual lifts should be kept as small as possible. Many small lifts are preferable to one large lift. The change in invert at each lift should not exceed 1,5 m. For vacuum sewers the minimum distances between lifts should be 6 m. Profile changes should be made where necessary to ensure that the pipe depth does not become excessive.

5.3.3 *Hydro-pneumatic design*

The system design shall achieve a specified minimum partial vacuum, under no flow conditions, at each interface valve.

If national regulations prohibit the discharge of gross solids into sewers the specified minimum partial vacuum shall be 20 kPa. Elsewhere the minimum partial vacuum shall be 25 kPa. The vacuum recovery time shall not exceed the specified maximum. The system shall be designed to achieve automatic restart after mechanical or electrical breakdown.

NOTE. With current technology the specified maximum vacuum recovery time should not exceed 30 min.

5.3.4 *Basis of design*

Sewage flow rates shall be based on local conditions. The client shall specify the flow rates taking account of infiltration into gravity drains. On request the designer shall state the average air and liquid flows for which the system is designed, the peak flow (litres per second) used in the design and how the dynamic and static head losses have been calculated.

5.3.5 *Vacuum station*

The number and capacity of the duty vacuum generators and forwarding pumps shall be selected to deliver the peak flows of air and sewage respectively. The minimum volume of the vacuum reservoir shall be calculated taking account of the maximum start frequency of the vacuum generators and forwarding pumps and the range of operational pressure. This reservoir capacity shall be provided by the vacuum vessels and the available vacuum sewer capacity.

5.3.6 *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 annex G (informative). A bibliography is given in annex H (informative).

5.3.7 *Application of vacuum sewerage*

Guidance on the circumstances which warrant particular consideration of the use of a vacuum sewerage system are given in annex I (informative).

6 Installation

6.1 Installation

The installation of the vacuum pipeline and ancillaries shall be in accordance with the provisions of the prEN 805 relating to the istallation of pipelines.

6.2 Tolerances

When the gradient of the pipe is less steep than 1 in 150, pipes shall not deviate vertically by more than +12 mm from the designed profile. Any deviation shall not create backfalls. Proposed changes to the designed pipeline profile shall be checked to ensure that the system can still operate within the design parameters.

NOTE. In-situ bending of flexible pipe should not cause over-stressing.

6.3 Warning and location system

A warning system, (tape or netting), shall be laid in the trench above the pipeline.

Where the pipeline material is non-conducting, a location system shall be provided.

7 Testing and verification

7.1 Testing of interface units

7.1.1 Every interface unit, comprising the interface valve, controller and sensor shall be tested to ensure that it functions correctly.

7.1.2 The interface unit shall have a proven ability to undertake a specified number of cycles without attention other than the manufacturer's recommended maintenance and still function effectively. The specified number of cycles shall be the greater of

a) the number of cycles needed to evacuate 3000 m^3; or

b) 250 000 cycles.

Where new valves or controllers are introduced or significant changes are made to proven valves, laboratory tests shall be undertaken under simulated working conditions. The laboratory tests, using clean water and air, shall demonstrate that the complete interface unit can successfully complete the specified number of cycles defined above without attention other than the manufacturer's recommended maintenance and still function effectively.

The tests shall, if required, also establish that the interface valve will operate satisfactorily when submerged, fail safe in the closed position and that the flow path is not obstructed by the valve mechanism. The submergence test shall only be undertaken when the interface unit is to be installed in the collection chamber sump or when a flood proof interface unit is specified. A test procedure is given in annex A (normative).

7.1.3 ***In-situ testing of interface units***

The manufacturer shall provide evidence that the complete valve mechanism will function effectively in the normal working environment.

7.2 Testing of pipelines

Regular vacuum testing of all service connections and vacuum sewers shall be undertaken as work proceeds and when it is completed. A test procedure is given in annex B (normative).

7.3 Water tightness

7.3.1 Prior to commissioning an internal visual examination shall be made of all collection chambers. There shall be no evidence of water ingress via the cover and frame. The walls and floors shall have no sign of ingress of water.

7.3.2 If required, collection chambers shall be tested against an internal water pressure. A test procedure is given in annex C (normative).

7.4 Commissioning tests

During commissioning tests may be undertaken to check:

a) noise;

b) the minimum vacuum at the extremities of the system;

c) the air/sewage ratio;

d) the vacuum recovery time;

e) the ability of the system to automatically restart;

f) the operation of vacuum station controls and alarms;

g) the time taken to replace interface valves and forwarding pumps.

A test procedure is given in annex D (normative).

8 Commissioning

8.1 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.

8.2 As constructed drawings of the system and an operator's manual shall be provided. Guidance on the contents of the manual is given in annex F (informative).

8.3 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.

8.4 The manufacturer shall make available facilities for operator training. The training shall cover system installation, operation and maintenance and record keeping and interpretation. Annex F (informative) contains an example of a maintenance schedule.

8.5 The contractor shall demonstrate that all the equipment functions satisfactorily.

8.6 The commissioning tests set out in annex D (normative) shall be undertaken if requested.

Annex A (normative)
Testing of interface unit

A.1 Preliminary checks

A.1.1 All interface unit shall be selected at random from at least 10 units ready for delivery.

A.1.2 The interface unit shall be connected to a vacuum source and tested to determine that the valve will not operate unless the partial vacuum exceeds 15 kPa below atmospheric by reducing the vacuum to that level and determining that the valve does not then cycle. Checks shall also be undertaken to establish that the valve closes when the vacuum is released.

A.2 The endurance test

A.2.1 *Test rig description*

The interface unit installed in a collection chamber, shall be connected to a vacuum source capable of maintaining the vacuum within the normal operating range of the valve and with a recovery time at the valve of less than 50 % that of the valve cycle. A means of discharging or recirculating the water without interrupting the operation of the rig shall be provided.

A.2.2 *Test procedure*

The batch-volume of the collection sump shall be determined. The test shall be conducted using clean water. The valve shall be fitted with at least one cycle counter which shall be read or set to zero and the valve and counters shall all be security sealed against tampering. The water flow to the collection sump shall then be adjusted such that the test will be complete within one year and the sensor set such that at least the batch volume is evacuated at each valve cycle. The air water ratio shall not be less than 1,5. The test shall cease after the specified number of cycles as defined in clause **7.1.2**. If the specified number of cycles is not achieved the interface unit shall be recorded as failing the test. During the course of the test the valve shall receive no attention other than the manufacturer's recommended maintenance.

A.3 Resistance to blockage test

A.3.1 The test requires selected foreign matter to be cycled through the interface valve. The test is not required if national regulations prohibit the discharge of gross solids into sewers.

A.3.2 The following foreign matter shall be placed in the collection sump, piece by piece over 10 cycles, in random order:

– cotton handkerchiefs:	(400 ± 35) mm × (400 ± 35) mm; (15 ± 5) g	2 pieces;
– plastic bag:	(300 ± 30) mm × (270 ± 20) mm	1 piece;
– plastic bag:	(200 ± 20) mm × (150 ± 15) mm	1 piece;
– metallic crown corks:	nominal diameter 25 mm	2 pieces;
– male condom:		2 pieces;
– sanitary towels:	by dry weight (40 ± 10) g	(number to suit);
– disposable baby's nappy:	complete with water-proof backing, by dry weight (45 ± 5) g	1 piece.

All absorbent material shall be submerged in water for not less than 1 min or more than 3 min before being placed in the sump.

A.3.3 The test rig shall be run for another 10 cycles after the last piece of the foreign matter has been placed in the sump.

A.3.4 The test shall be conducted five times.

A.3.5 The results of the tests shall be reported and shall state what foreign matter remained in the sump after each test and whether the valve failed to close or the pipework contained foreign matter at the end of a test. A failure to close or the retention of solid matter in the suction pipework at the end of a test shall constitute a failure except that, where local or national regulations prohibit the discharge of gross solids to sewers, the retention of foreign material at the suction pipe inlet shall not constitute a failure.

A.4 Submergence test

A.4.1 The vacuum shall be released and the collection chamber sump shall be filled with water sufficient to cover the top of the interface valve body by 300 mm. The breather tube shall not be submerged. After remaining submerged for 24 h the vacuum shall be restored and the interface valve mechanism cycled 20 times. The test shall be undertaken 3 times.

A.4.2 The interface valve shall fail the submergence test if it fails to complete 20 cycles in any test or fails to function correctly.

Annex B (normative)
Testing of pipelines

B.1 Calibrating test equipment

B.1.1 Prior to carrying out a vacuum test a check shall be made to ensure that the test equipment, is in good working order and correctly fitted to the vacuum sewer or service connection.

B.1.2 The permitted loss of vacuum in tests shall be corrected to allow for changes in temperature and barometric pressure during the course of the test. Pipe temperatures and barometric pressure shall be recorded at the commencement and end of the test and at hourly intervals between.

B.2 General

Except where phased completion takes place, all vacuum testing and cleansing of service connection, vacuum sewers and vacuum vessels shall be complete prior to the installation of the interface valves. Where phased completion takes place only the first phase shall be tested in this manner. For each subsequent phase only the additional service connections and vacuum sewers shall be vacuum tested and cleansed prior to installation of the interface valves.

B.3 Interim testing

B.3.1 ***Systems without inspection pipes***

After not more than 450 m of vacuum pipeline has been laid, the vacuum sewers and service connections laid shall be subjected to a partial vacuum of (70 ± 5) kPa below atmospheric, allowed to stabilize for at least 30 min and then shall not lose more than one percent of the test vacuum pressure per hour for a two hour test period. The vacuum station may be isolated from the pipeline for this test.

B.3.2 ***Systems with inspection pipes***

After not more than 450 m of vacuum pipeline has been laid the vacuum sewers and service connections laid shall be subjected to a partial vacuum of (70 ± 5) kPa below atmospheric, allowed to stabilize for at least 30 min and then shall not lose more than 5 % of the test vacuum pressure in a one hour test period. The vacuum station may be isolated from the pipeline for this test.

B.3.3 If any section fails the test it shall be reworked and the test successfully completed.

B.4 Final testing

B.4.1 ***Systems without inspection pipes***

When all service connections and vacuum sewers have been laid the entire system including the vacuum station shall be subjected to a partial vacuum of (70 ± 5) kPa below atmospheric, allowed to stabilize for at least 30 min and then shall not lose more than 1 % of the test vacuum pressure per hour for a 4 h period.

B.4.2 ***For systems with inspection pipes***

When all service connections and vacuum sewers have been laid the entire system including the vacuum station shall be subjected to partial vacuum of (70 ± 5) kPa below atmospheric, allowed to stabilize for at least 30 min and then shall not lose more than 5 % of the test vacuum pressure per hour for a 1 h period.

Annex C (normative)
Collection chambers: internal water pressure test

C.1 All inlet and outlet pipes shall be plugged with water tight seals and the collection chamber filled with water to a level 500 mm below the surface level of the cover. The volume of the collection chamber up to this level shall be determined by calculation and/or measurement. A period of at least 2 h shall be allowed for absorption and stabilisation after which water shall be added from a measuring vessel at intervals of 5 min and the quantity required to maintain the original water level noted.

C.2 The collection chamber shall pass the test if the quantity of water added over a 3 h period is less than 0,2 % of the initial water volume.

Annex D (normative)
Commissioning tests

D.1 General

The commissioning tests shall be undertaken on each system after it has been started and is operating to the satisfaction of the contractor.

D.2 Noise

Noise shall be measured in accordance with the local or national regulations. If the noise level exceeds that permitted by local or national regulations the system shall fail the test.

D.3 Minimum vacuum and vacuum recovery time

A vacuum gauge with recorder shall be installed on the service connection at the upstream extremity of the system. The test shall be carried out for at least 24 h. The system shall fail the test if the partial vacuum is less than the specified minimum. The vacuum recovery times shall be recorded and the system shall fail the test if the time exceeds the specified maximum. The interface valve mechanism shall fail the test if it operates at a partial vacuum of less than 15 kPa below atmospheric.

D.4 Air/sewage ratio

D.4.1 The air/sewage ratio shall be determined over a period of at least 28 d.

D.4.2 If flow measuring devices have been installed the air and sewage flows shall be directly measured. In the absence of flow measuring devices the flows shall be calculated from the hours run by the vacuum generators and forwarding pumps and their rated capacity.

D.5 Automatic restart

The vacuum station shall be closed down for a period of 2 h during a peak flow period selected by the client. The collection sump at the extremity of the system shall be filled. The time from restarting the vacuum station until the sump is emptied shall be measured. If this time period exceeds 2 h the system shall fail the test.

D.6 Operation of vacuum station control alarms

D.6.1 The operation of the normal start level and stop level controls shall be monitored during one of the preceding tests.

D.6.2 The forwarding pumps shall be switched to manual control and switched off. The emergency stop level in the vacuum vessel or the sewage sump shall be checked to see that it stops the vacuum generator when the High Sewage Alarm is given. The forwarding pumps shall then be switched on and re-set to automatic; they shall empty the vacuum vessel to the 'start' level before the vacuum pump switches on.

D.6.3 The vacuum generator shall be switched off and the Low Level Alarm shall be monitored to check that it indicates when the vacuum has fallen below the pre-set value.

D.6.4 The emergency alarm shall be tested by undertaking the following checks in sequence:

a) switching off the vacuum generator;

b) switching off the forwarding pumps;

c) switching off the power supply;

d) switching the vacuum generator to manual control and measuring the time taken for the alarm to be given; it shall not exceed the maximum selected continuous running time for the generator.

The alarm shall activate for each of these checks.

D.7 Replacement times

D.7.1 The operatives shall attend a collection chamber from which the cover has been removed. A replacement interface valve and control system shall be to hand. The time taken to take out the interface valve and control system and install the replacement equipment shall be measured. The time shall not exceed 30 min.

D.7.2 The time taken to replace forwarding pumps shall only be measured if the pumps are installed inside the vacuum vessel. The measurement should be made when sewage flows are low. The time taken to stop the system, remove a forwarding pump, install a replacement pump and restart the system shall be measured. The time shall not exceed 4 h.

Annex E (informative)

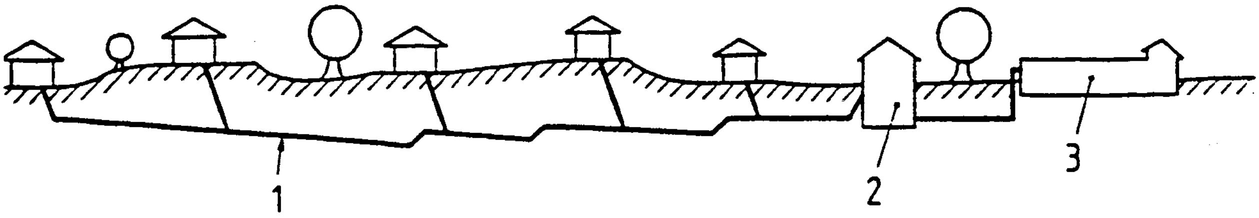
Typical configurations

E.1 Typical configurations

E.1.1 Typical configurations for vacuum sewerage systems and components are shown in the accompanying figures:

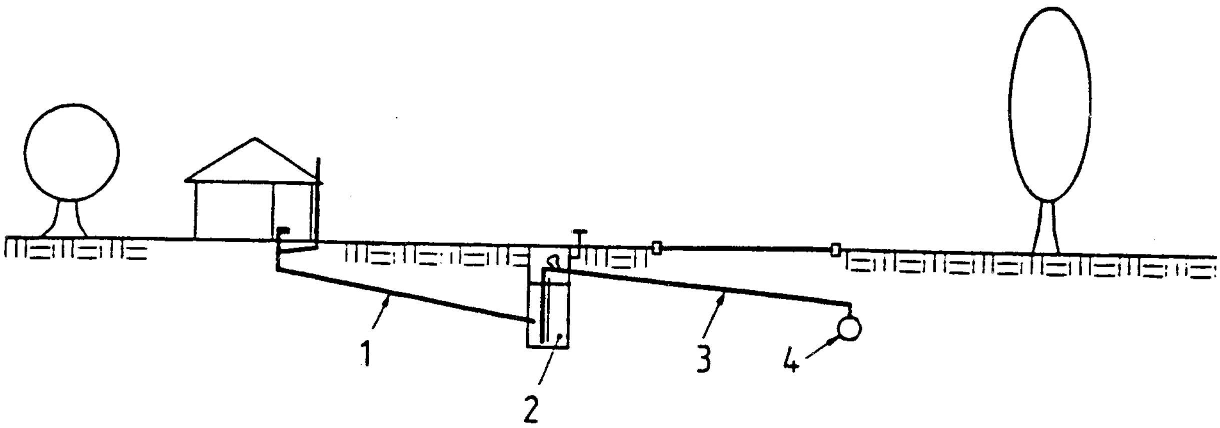
– Figure E.1	Vacuum sewerage system;
– Figure E.2	House connection;
– Figure E.3 a) to d)	Examples of collection chambers;
– Figure E.4	Multi-valve collection chamber;
– Figure E.5	Vacuum sewer profiles;
– Figure E.6	Examples of vacuum sewer profiles for uphill and downhill transport;
– Figure E.7 a) to e)	Examples of vacuum stations;
– Figure E.8	Vacuum sewer with inspection points.

E.1.2 Examples have been taken for illustrative purposes only from a variety of vacuum sewerage systems. The figures should not be interpreted as typical of a manufacturer's system or as defining the range of the system.



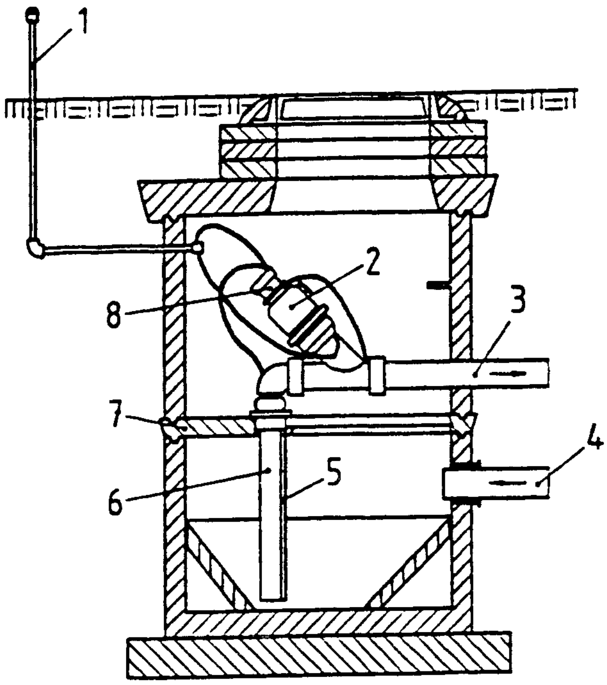
1 Vacuum sewer
2 Vacuum station
3 Seweage treatment works

Figure E.1 Vacuum sewerage system



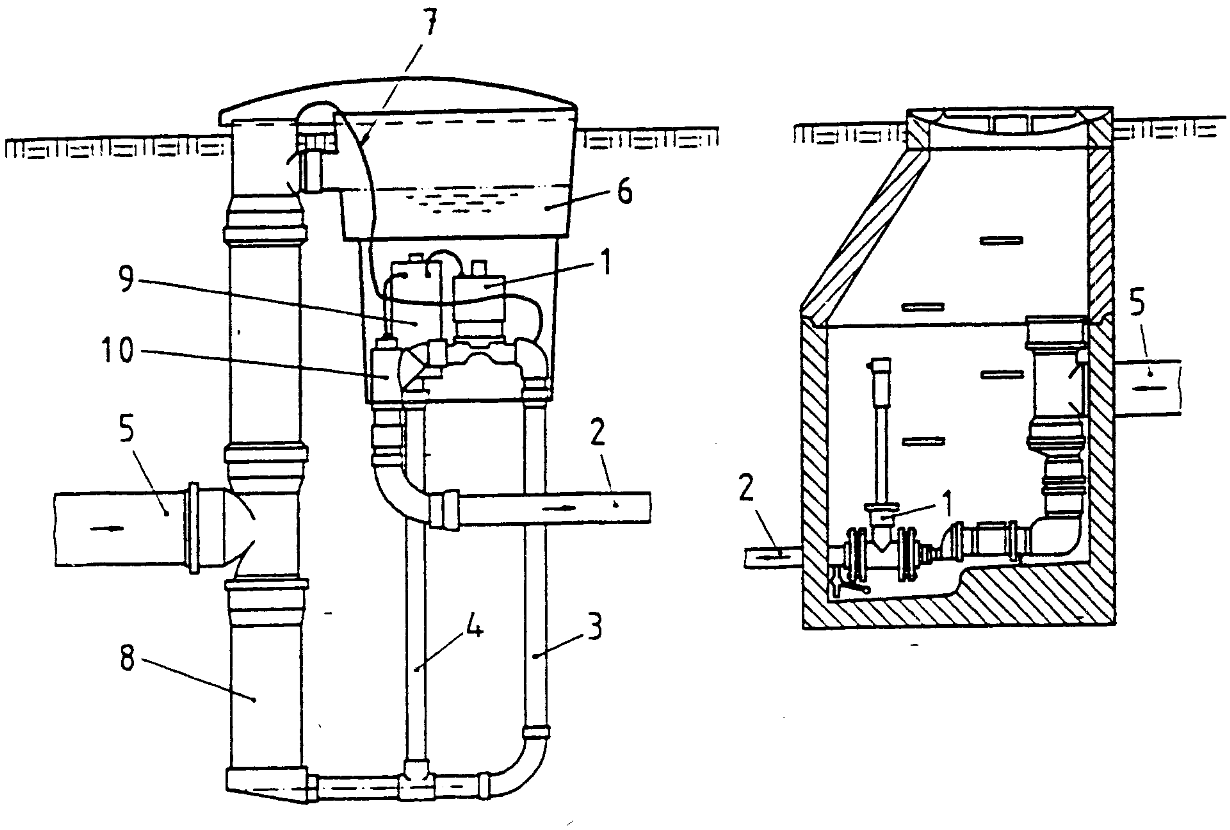
1 gravity drain
2 collection chamber
3 service connection
4 vacuum sewer

Figure E.2 House connection



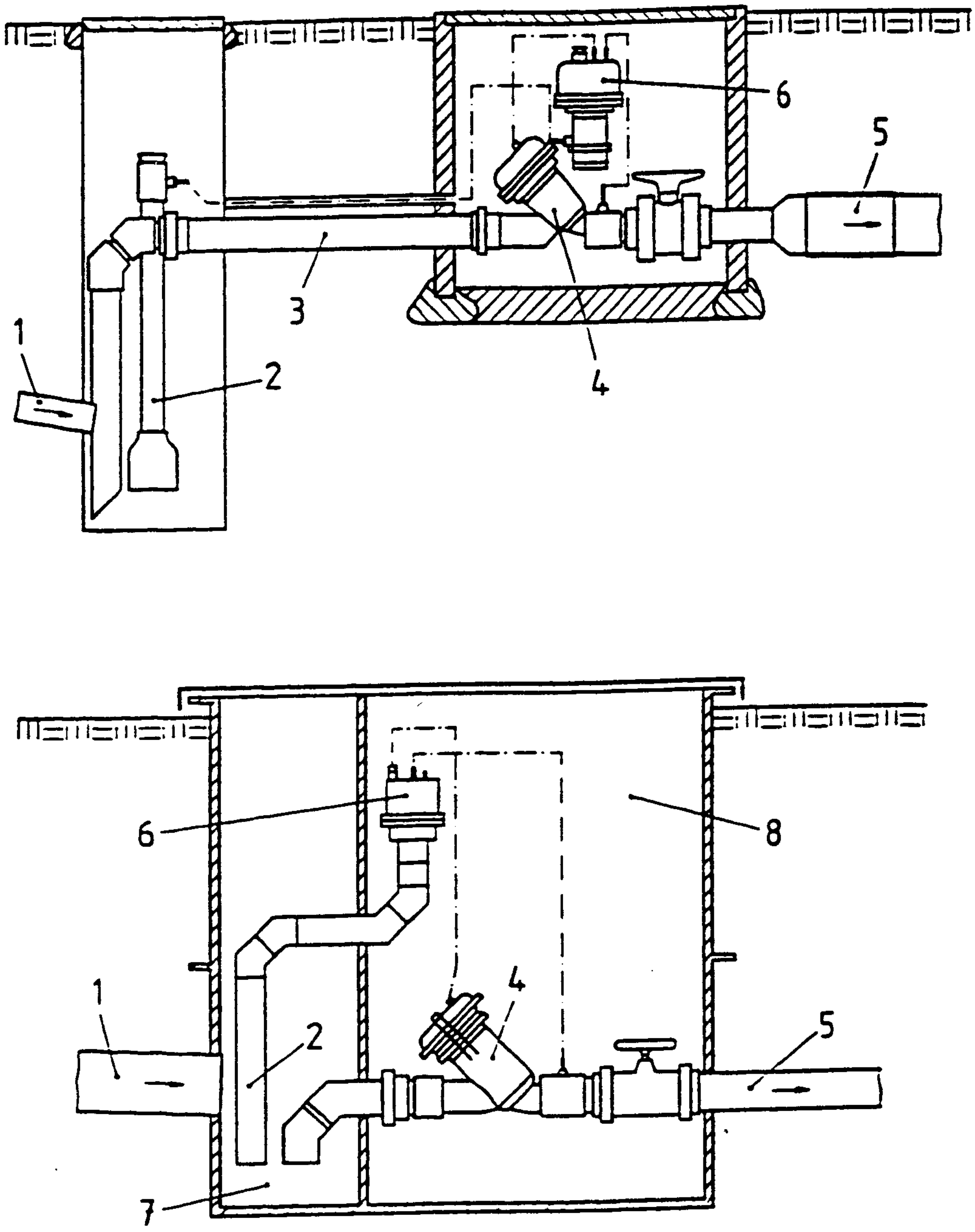
1 breather pipe
2 interface valve
3 to vacuum sewer
4 gravity inlet
5 sensor pipe
6 suction pipe
7 optional
8 control

Figure E.3 a) Collection chambers with interface valves vented through breather pipes



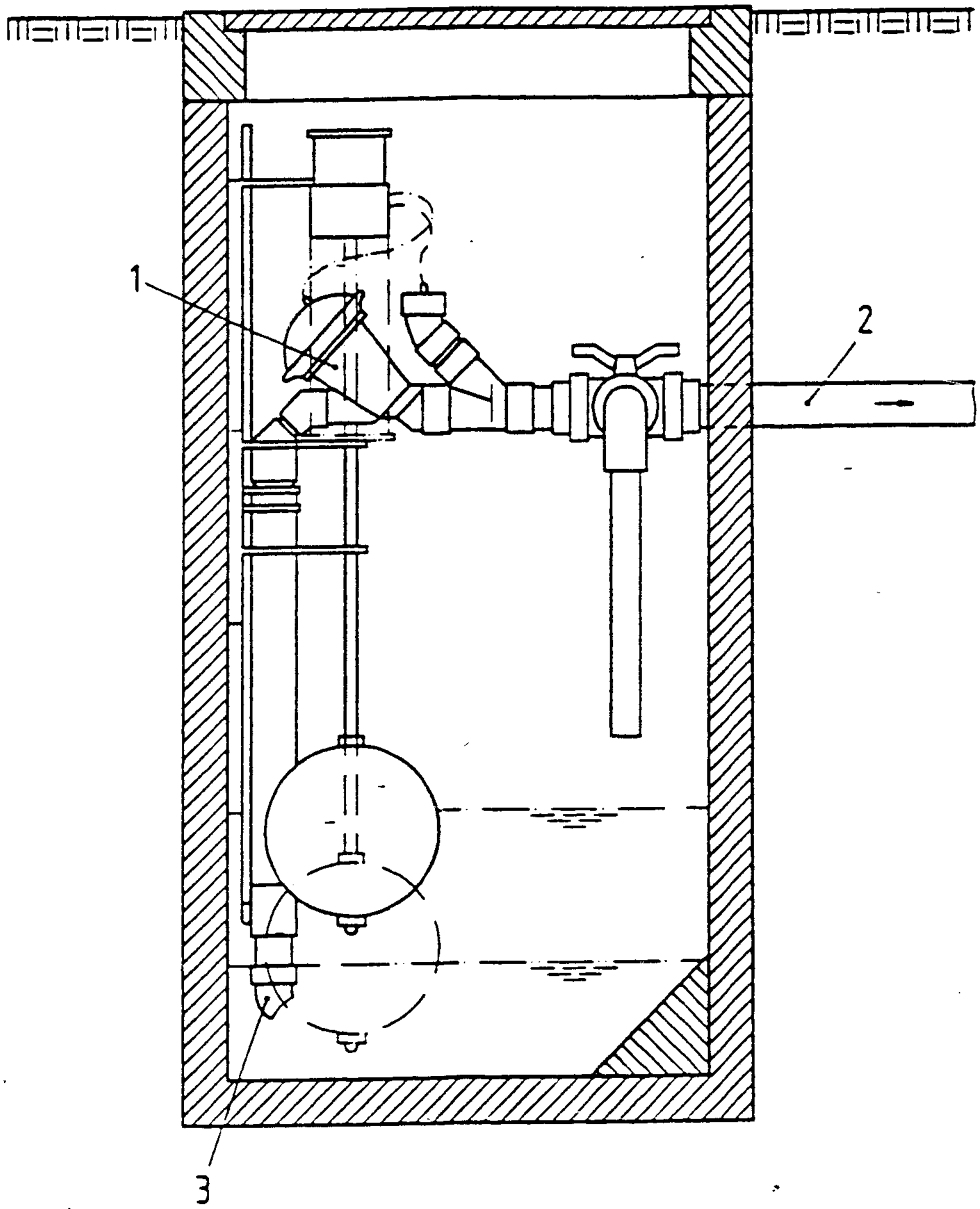
1 interface valve
2 to vacuum sewer
3 suction
4 sensor
5 gravity inlet
6 heat insulation
7 tube for aeration
8 sump
9 control
10 manual isolator

Figure E.3 b) Collection chamber with sump capacity provided in feed pipework



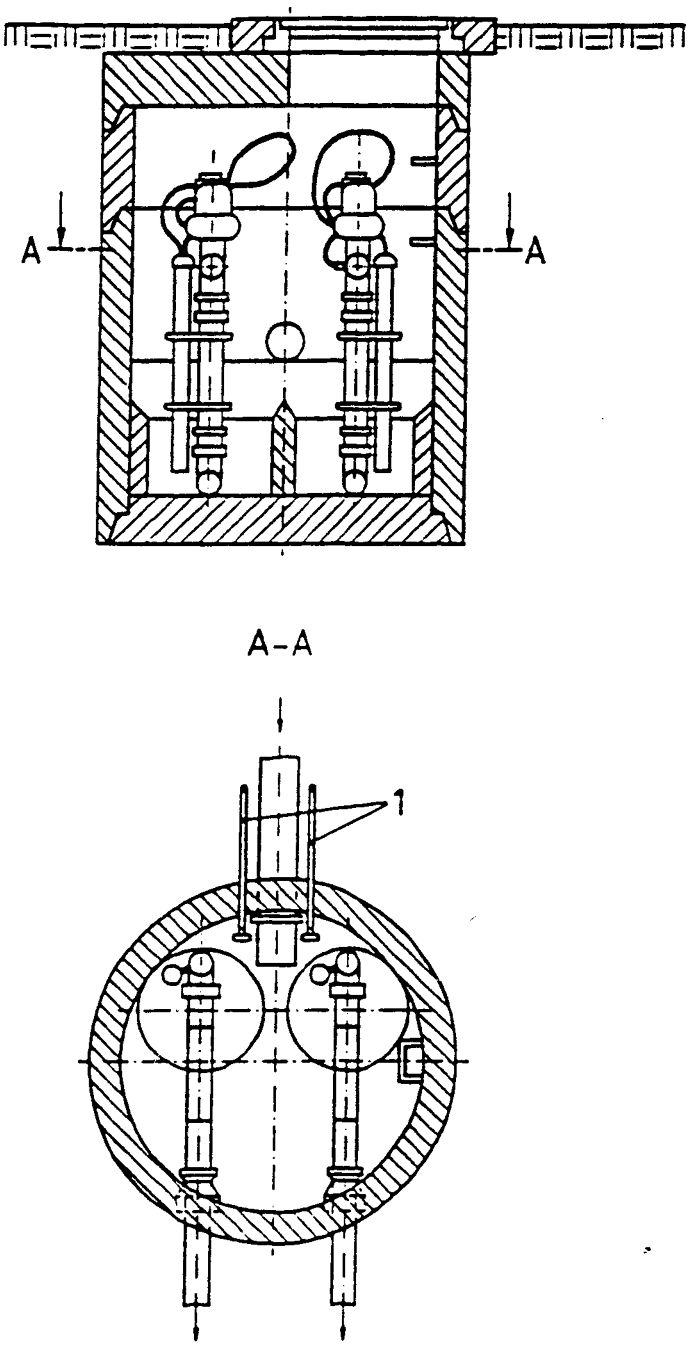
1 gravity inlet
2 sensor
3 suction
4 interface valve
5 to vacuum sewer
6 control
7 sump
8 valve chamber

Figure E.3 c) Collection chambers with separate valve pit



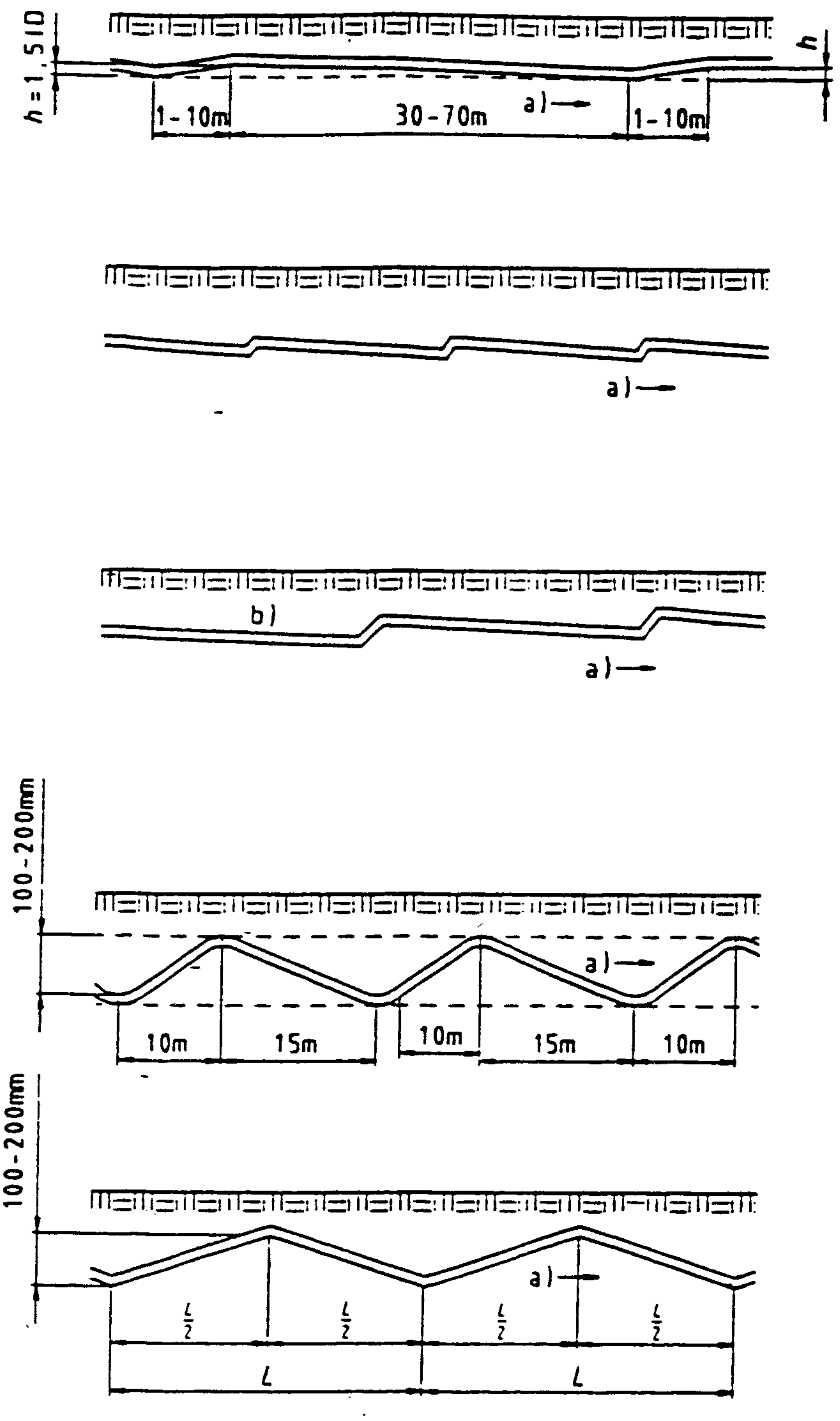
1 interface valve
2 to vacuum sewer
3 suction

Figure E.3 d) Collection chamber with interface valve activated by float



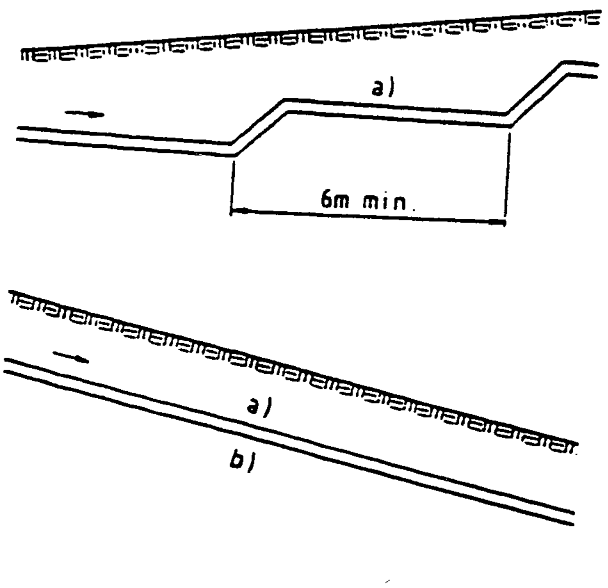
1 breather pipes

Figure E.4 Multi-valve collection chamber



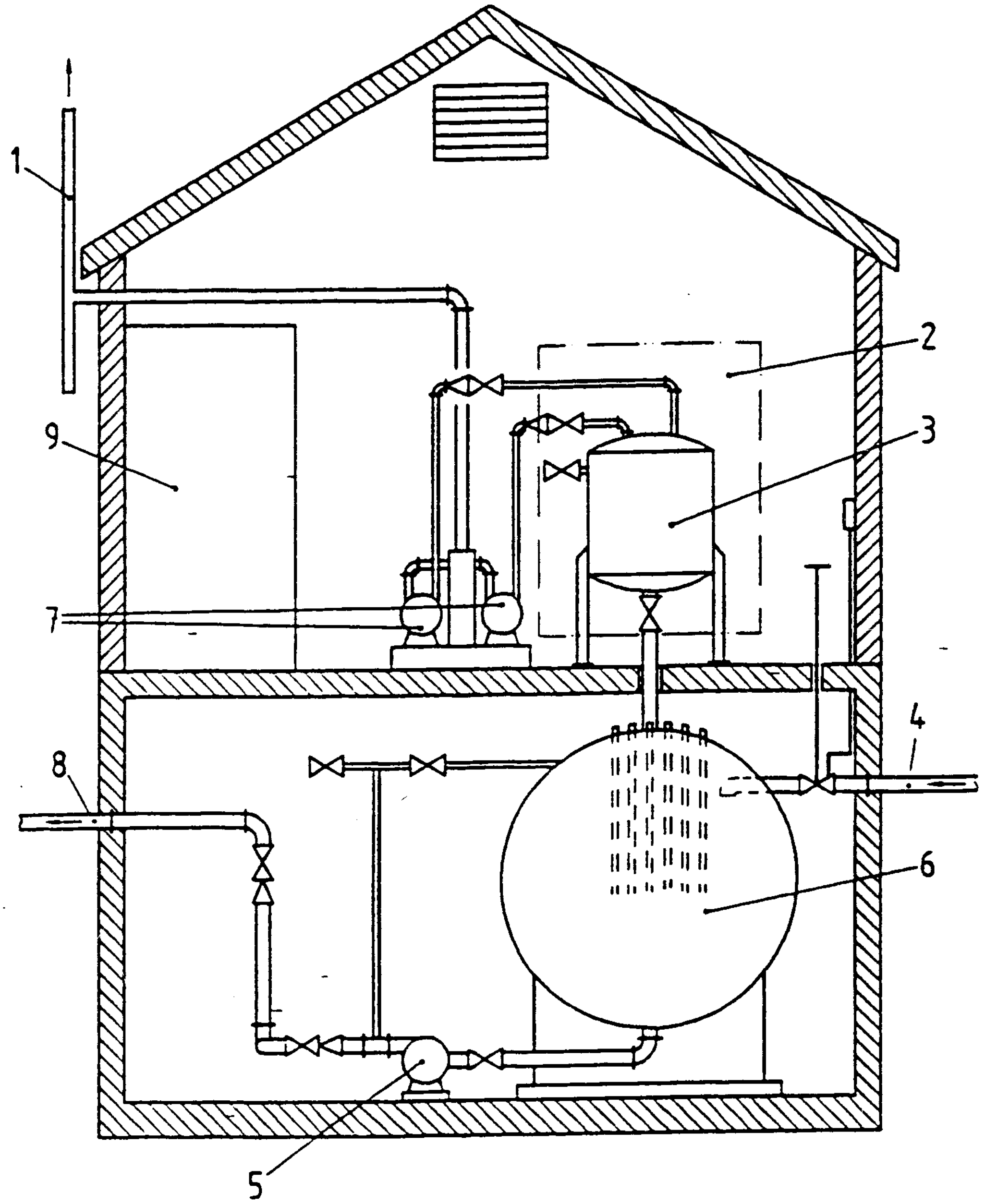
a) flow
b) 0,2 % minimum slope

Figure E.5 Vacuum sewer profiles (not to scale)



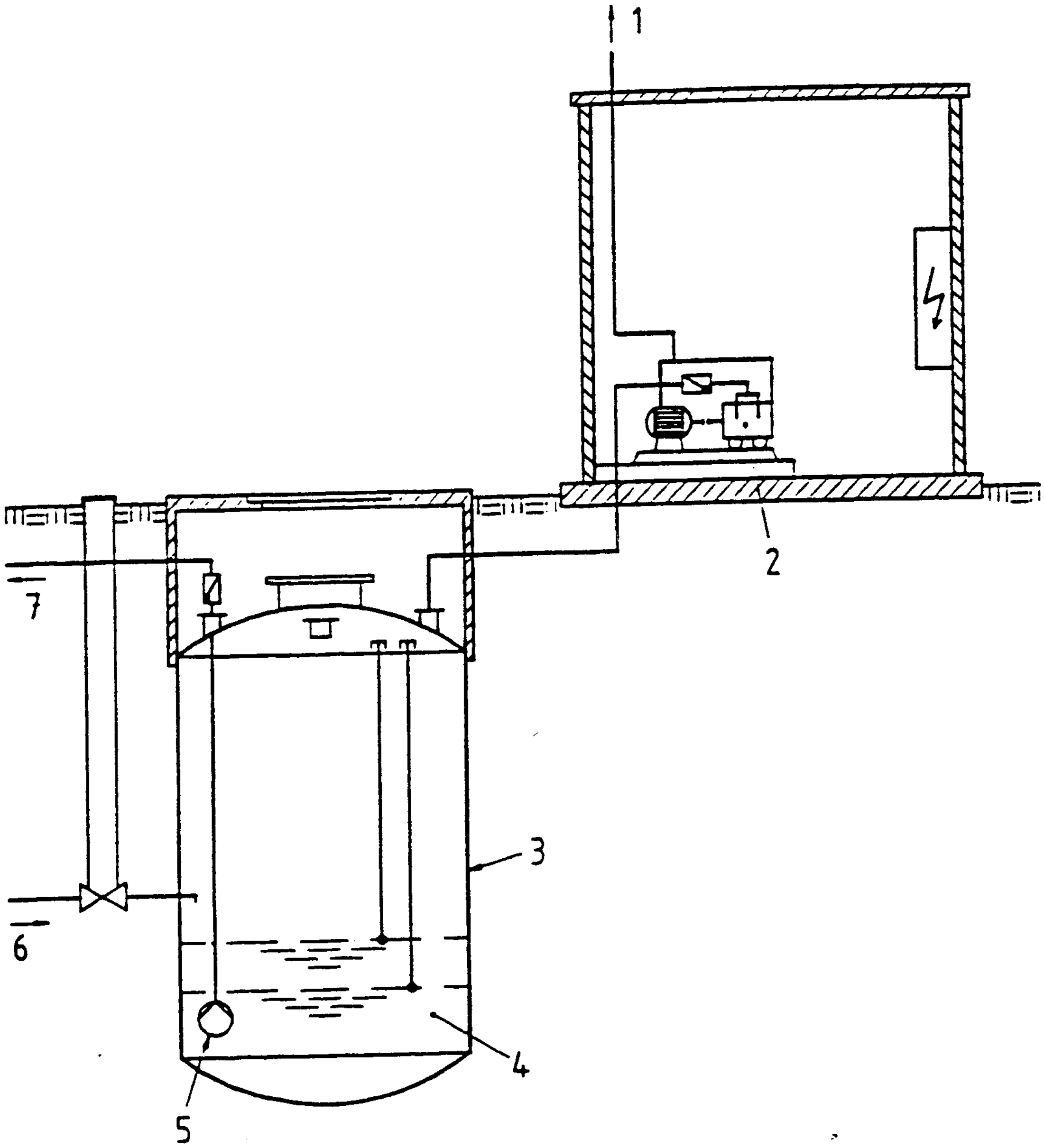
a) 0,2 % minimum slope
b) follow ground profile

Figure E.6 Examples of vacuum sewer profiles for uphill and downhill transport (not to scale)



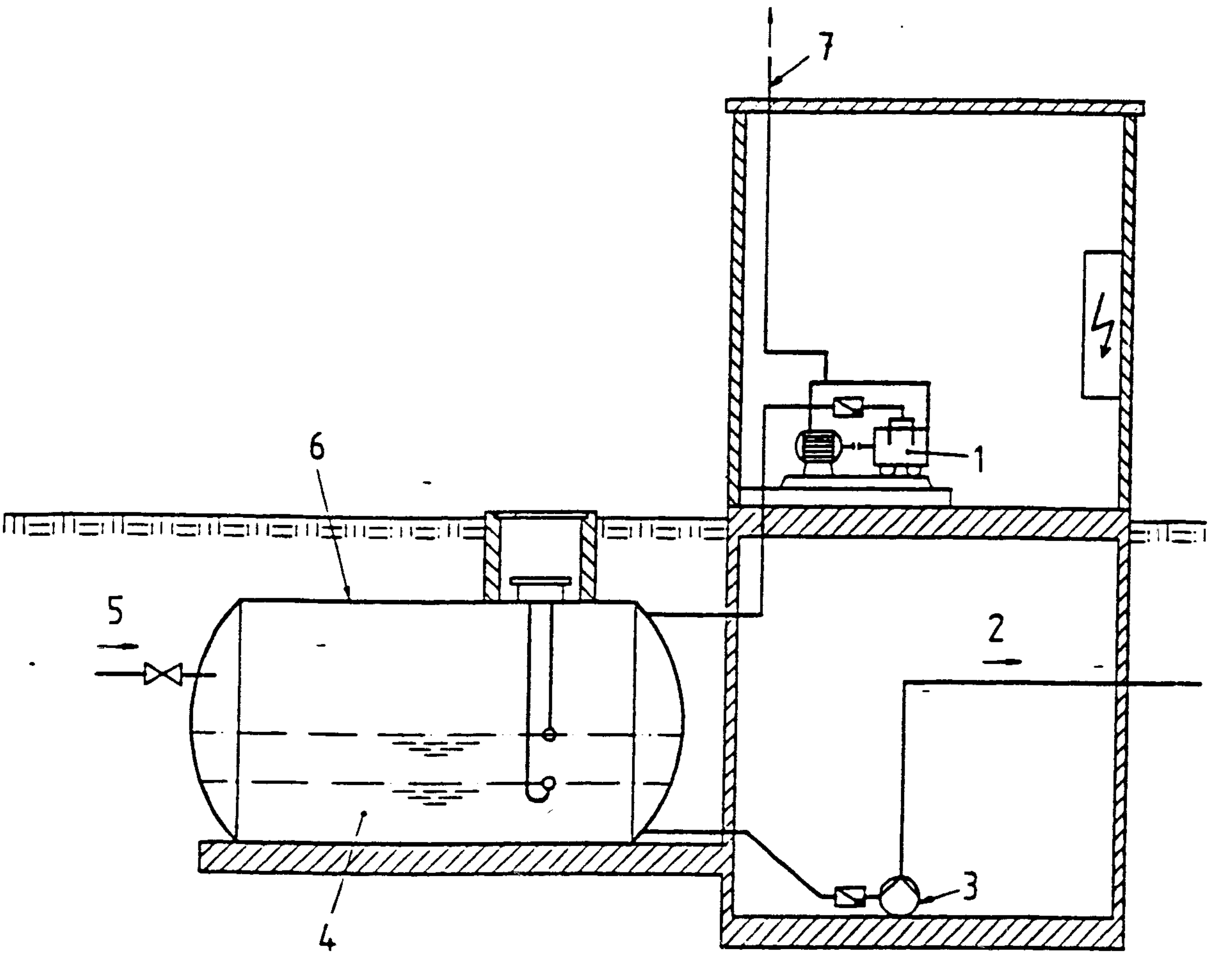
1 vent
2 where required
3 vacuum reservoir/moisture removal tank
4 vacuum sewers
5 forwarding pumps
6 vacuum vessel
7 vacuum pumps
8 rising main
9 control pane

Figure E.7 a) Example of vacuum station with housed collection vessel



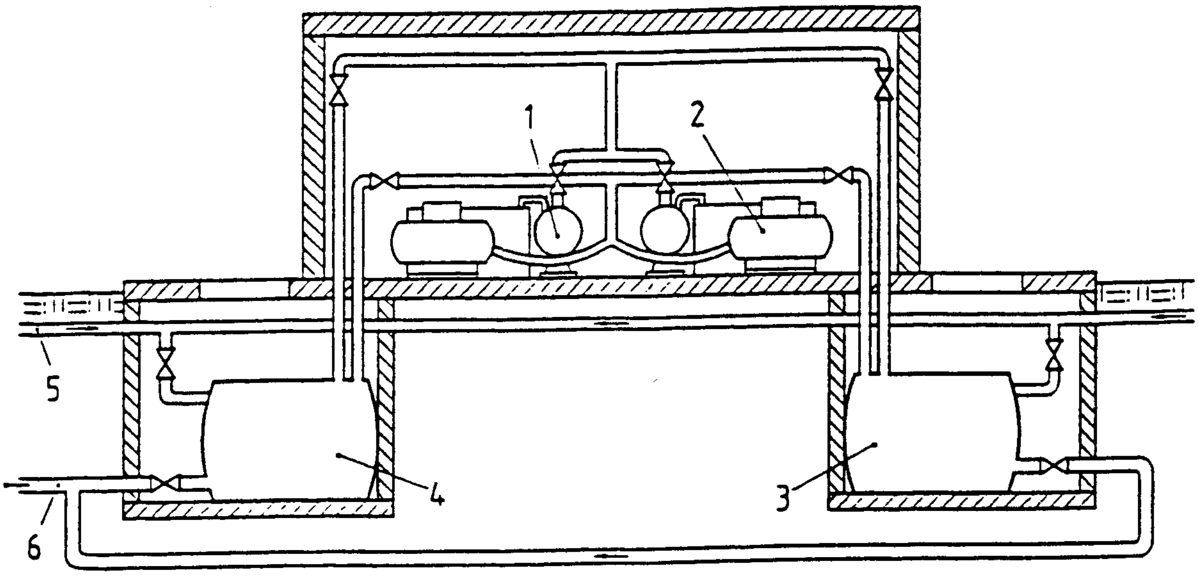
1 vent
2 vacuum pumps
3 vacuum vessel
4 sewage
5 submersible forwarding pump
6 from vacuum sewer
7 rising main

Figure E.7b) Example of vacuum station with vertical external vessel



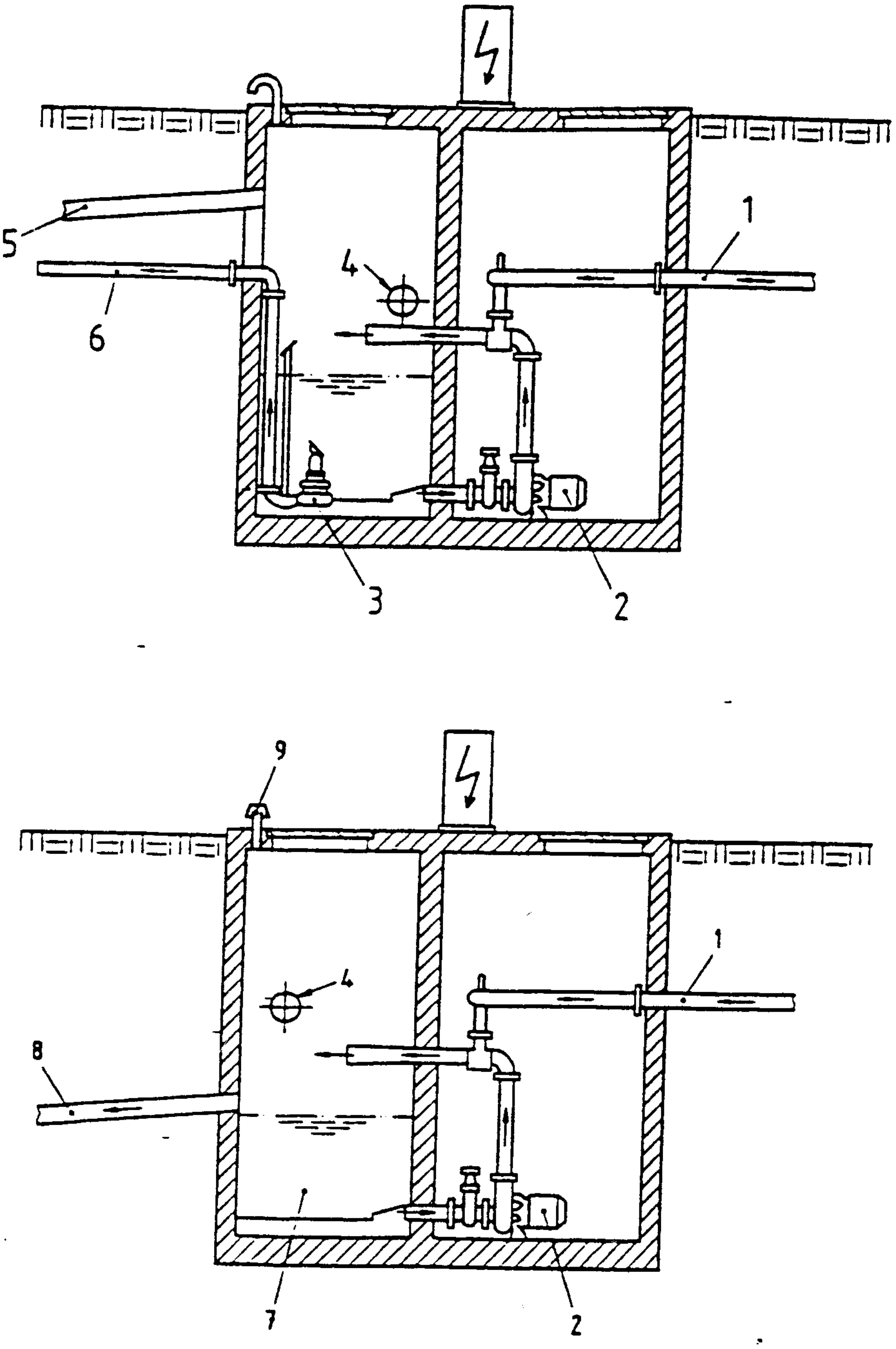
1 vacuum pumps
2 rising main
3 forwarding pumps
4 sewage
5 vacuum sewer
6 vacuum vessel
7 vent

Figure E.7 c) Example of vacuum station with horizontal external vessel



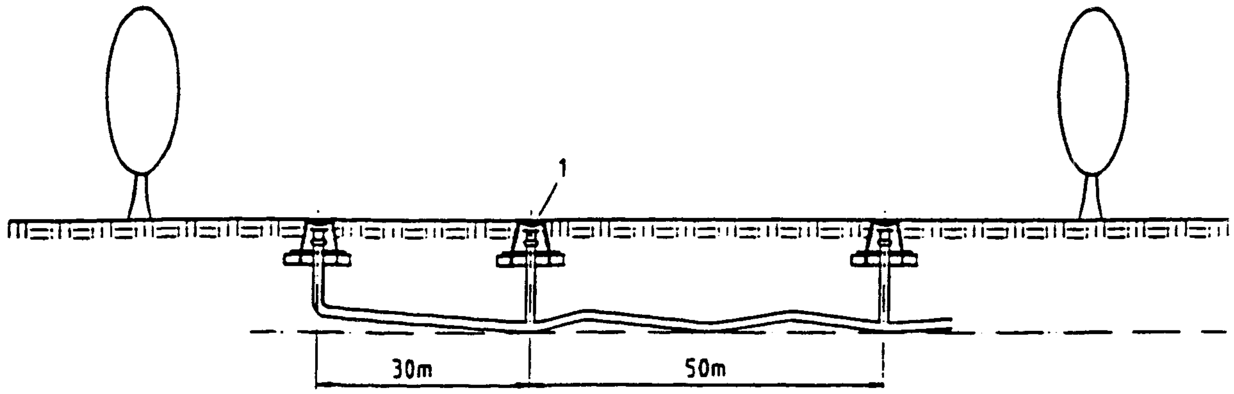
1 liquid-ring vacuum pumps
2 compressors
3 forwards sewage
4 collects sewage
5 vacuum sewer
6 rising main

Figure E.7 d) Example of vacuum station employing pressure vessels in lieu of forwarding pumps



1 vacuum sewer
2 ejector pumps
3 forwarding pump
4 gravity inlet
5 emergency overflow
6 rising main
7 sewage
8 gravity sewer
9 vent

Figure E.7 e) Example of vacuum station employing ejector pumps



1 inspection point

Figure E.8 Vacuum sewer profile with sewer inspection point (not to scale)

Annex F (informative)

Operational and maintenance information

F.1 Maintenance

Maintenance requirements will vary depending on the system employed. An example of a maintenance schedule is set out below:

Collection chamber:

– 6 monthly: visual internal inspection of chamber and contents;

– annually: wash down sump and fittings; purge breather;

– 5 yearly: strip down interface valve and renovate as required.

Vacuum station:

– 40 times a year: visual inspections; record hours run by vacuum and forwarding pumps and power consumption;

– 12 times a year: visual inspection and record keeping; routine operational maintenance;

– annually: mechanical and electrical maintenance.

The frequency of inspections may be reduced if telemetry monitoring is employed.

F.2 Operator's manual

The contents of the operator's manual will vary depending on the system employed but it is suggested that the following topics should be covered.

a) The interface valve and its adjustment:

1) field adjustments/controller timing;

2) controller sensor unit.

b) The vacuum station:

1) vacuum generators;

2) forwarding pumps;

3) instrumentation.

c) System malfunctions and alarms:

1) power failure;

2) sewerage system;

3) interface valve;

– fails to close;

– fails to open.

4) Vacuum station:

– loss of vacuum;

– forwarding pump problems.

d) Record keeping.

e) Equipment suppliers and manufacturers.

F.3 Power consumption

The major factors affecting power consumption are:

a) sewage flows;

b) the topography of the area and the extent of the system;

c) the air/sewage ratio;

d) the type of vacuum generator;

e) the type of forwarding pump;

f) the integrity of the vacuum sewer and interface valves.

Typically, power consumption ranges from 0,2 to 1 kW·h/m^3 of sewage which, assuming sewage discharges of 150 1/person/d, is equivalent to 10 to 50 kW·h/person/year.

Annex G (informative)

Sources of additional information

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Annex H (informative)

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Annex I (informative)

Application of vacuum sewerage

Particular consideration should be given to the use of the vacuum system in one or more of the following circumstances:

a) insufficient natural slope i.e. in flat countryside or to serve low-lying communities;

b) isolated, low-density communities;

c) poor subsoil e.g. high groundwater water table, unstable soil or rock condition;

d) obstacles to the sewer route e.g. utility services, waterways;

e) in aquifer protection zones;

f) where there are only seasonal flows e.g. in holiday resorts;

g) where it is necessary to minimize the impact of construction work.

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List of references

See national foreword.

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