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Classification and characteristics of techniques for renovation and repair of drains and sewers

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/505, Wastewater engineering.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Classification and characteristics of techniques for renovation and repair of drains and sewers

Classification et caractéristiques des techniques de rénovation et de réparation des réseaux d'évacuation et d'assainissement

Klassifizierung und Eigenschaften von Techniken für die Renovierung und Reparatur von Abwasserkanälen und -leitungen

This European Standard was approved by CEN on 30 October 2010.

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Foreword

This document (EN 15885:2010) 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of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

It provides an overview of systems used for renovation and repair of drains and sewers, regardless of the material used. In respect of sewer renovation techniques using plastics materials only, it reproduces definitions and other information (but no requirements) contained in EN ISO 11295. Due to their continuous development the most up-to-date information on these particular techniques may be contained in either this document or EN ISO 11295, whichever is the latest dated edition. Regarding general requirements for drain and sewer systems and existing standards and draft standards on the subject of rehabilitation of drain and sewer systems, information in summary form is available in CEN/TR 15128.

For management and control of rehabilitation activities in drains and sewers a European Standard is in preparation in CEN/TC 165/WG 22.

This document refers to existing EN product standards to the extent available for the techniques and materials covered.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a system for the classification of techniques for renovation and repair of drains and sewers outside buildings, operated under gravity or pressure, including pipes, connections and manholes. It defines and describes families of techniques and their different generic methods and materials used.

This European Standard does not describe specific products.

For each technique family it lists relevant existing standards, materials and applications and outlines characteristics including installation aspects, structural and hydraulic capabilities and site impact.

Necessary work on the existing pipe prior to renovation and repair is outside the scope of this European Standard.

This European Standard provides information needed to determine viable options for identification of the optimal technique with regard to a given set of renovation and repair objectives.

NOTE It is the responsibility of the designer to choose and design the renovation and repair systems.

It does not specify the calculation methods to determine, for each viable technique, the required amount of lining material needed to secure the desired performance of the renovated pipeline.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 752:2008, *Drain and sewer systems outside buildings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
rehabilitation
measures for restoring or upgrading the performance of existing drain and sewer systems

[EN 752:2008, 3.50]

3.2
renovation
work incorporating all or part of the original fabric of the drain or sewer by means of which its current performance is improved

[EN 752:2008, 3.52]

3.3
repair
rectification of local damage

[EN 752:2008, 3.53]

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3.4
technique family
grouping of renovation or repair techniques which are considered to have common characteristics for classification purposes

3.5
lining
process of renovating an existing pipeline by introducing material on the inside

3.6
liner
lining pipe after installation

[EN ISO 11295:2010, 3.2]

3.7
lining pipe
pipe inserted for renovation purposes

[EN ISO 11295:2010, 3.1]

3.8
lining system
lining pipe and all relevant fittings inserted into an existing pipeline for the purposes of renovation

[EN ISO 11295:2010, 3.3]

3.9
lining with continuous pipes
lining with pipe made continuous prior to insertion, and which has not been shaped to give it a cross-sectional diameter smaller than its final diameter after installation

[ISO 11296-1:2009, 3.2.1]

3.10
lining with close-fit pipes
lining with a continuous pipe for which the cross-section is reduced to facilitate installation and reverted after installation to provide a close fit to the existing pipe

[ISO 11296-1:2009, 3.2.2]

3.11
lining with cured-in-place pipes
lining with a flexible tube impregnated with a thermosetting resin, which produces a pipe after resin cure

[ISO 11296-1:2009, 3.2.3]

3.12
lining with discrete pipes
lining with short lengths of pipe which are jointed to form a continuous pipe one by one during insertion

3.13
lining with spirally-wound pipes
lining with a profiled strip, spirally wound to form a continuous pipe after installation

[ISO 11296-1:2009, 3.2.5]

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3.14
lining with a rigidly anchored inner plastics layer
lining with a single rigid annulus of structural cementitious grout formed behind an inner plastics layer permanently anchored to the grout

3.15
lining with pipe segments
lining with prefabricated segments bonded to the existing pipe, which either:

a) have longitudinal joints and cover the whole of the pipe circumference, or

b) cover only part of circumference

3.16
lining with sprayed or cast-in-place material
lining by applying cementitious or polymeric material, with or without reinforcement, directly onto the inside surface of the host pipe and/or manhole, by manual or mechanical (including robotic) means

3.17
non-stabilising repair
repair where the materials applied have a sealing effect but do not enhance structural stability

3.18
stabilising repair
repair where the materials applied have a sealing effect and can enhance structural stability

3.19
repair by grout injection
filling of voids in existing pipe and/or surrounding ground by injection of grout over all or part of the perimeter of the sewer

NOTE Two different methods can be distinguished:

a) injection directly into a brickwork or masonry pipe structure;

b) injection of the soil around the pipe.

3.20
repair by injection sealing
repair of leakage at a crack, joint or lateral connection by resin or grout injection, with or without the aid of a packer

3.21
repair with cured-in-place patch
repair by local lining with a flexible tube impregnated with a thermosetting resin which produces a short length of pipe after resin cure

3.22
repair with lateral connection collar
repair of a connection between lateral and main pipe by installing a cured in place collar

3.23
repair with trowelled material
repair of local structural defects effecting part of the drain or sewer cross-section by trowelling material directly onto the wall or into the defect of the existing pipeline by manual or mechanical means

3.24
repair with internal mechanical devices
repair with internal mechanical seals or re-rounding clips

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3.25
repair with internal mechanical seal
sealing of local pipe damage and/or joints by use of an internal elastomeric seal held in place by compression rings

3.26
repair with mechanical re-rounding clip
restoration of pipe roundness by insertion of an overlapping or hinged metal ring, which is expanded hydraulically and locks into place to permanently reverse local cross section deformation of circular pipe

3.27
flow diversion
temporary abatement of all flows into the section of pipeline to be renovated or repaired by bypassing or other means

3.28
maintenance
routine work undertaken to ensure the continuing performance of drain and sewer systems

[EN 752:2008, 3.40]

4 Symbols and abbreviations

SEL	structural integrity based on external loads capacity
G	gravity pipeline applications
P	pressurized pipeline applications
SIL	structural integrity based on internal loads capacity
EW	excavation works
NM	non man entry
ME	man entry
CS	circular shape
NC	non circular and circular shapes possible
CCTV	closed circuit television
UP	unsaturated polyester
EP	epoxy
VE	vinylester
PE	polyethylene
PVC-U	unplasticized poly(vinyl chloride)
PP	polypropylene
EPDM	ethylene-propylene-diene monomer
GRP	glass reinforced plastics
GRC	glass reinforced cement

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PUR polyurethane

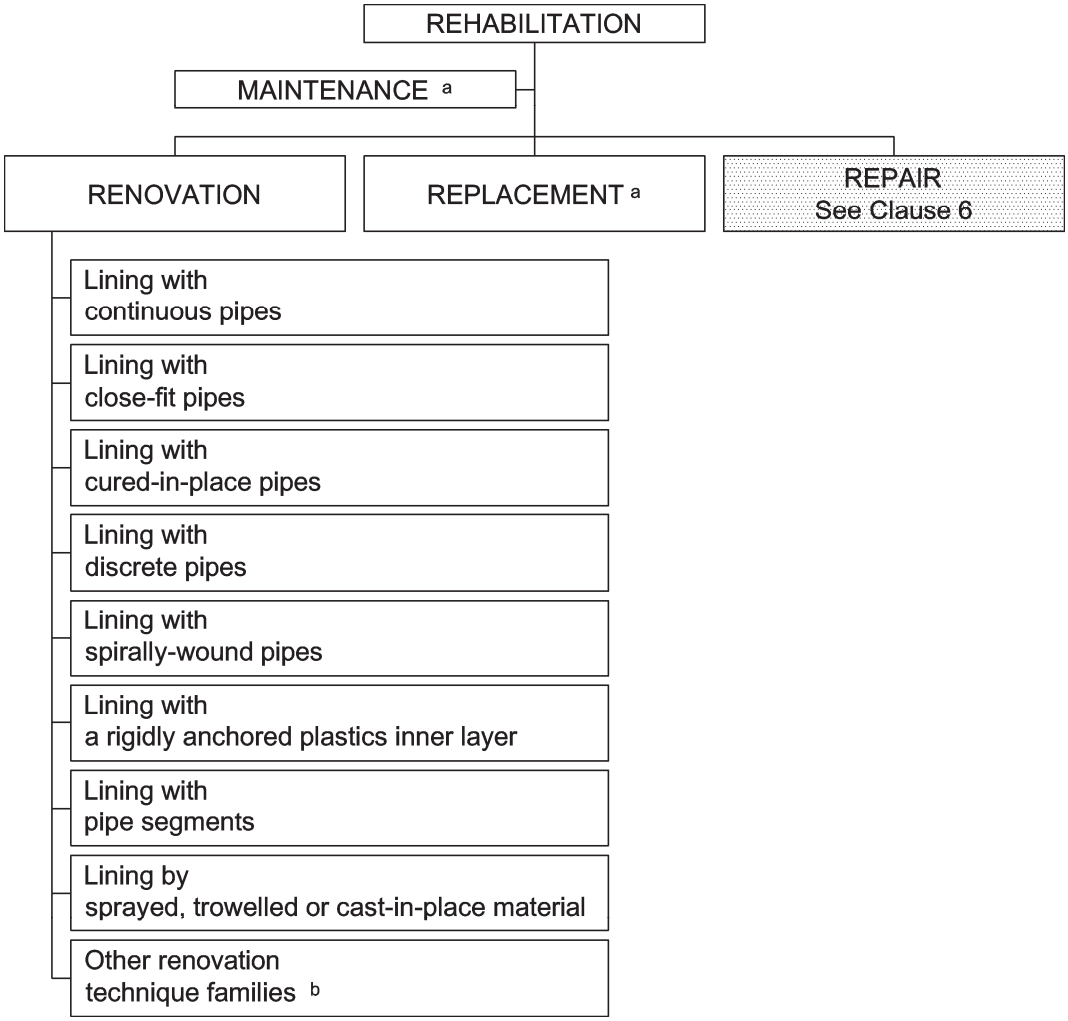
PCC polymer concrete

5 Classification of renovation techniques for drains and sewers

5.1 General

Renovation technique families within the scope of this European Standard are shown in Figure 1. This clause establishes a classification of renovation techniques into families, where renovation is applied to continuous lengths of drain or sewer usually between two or more access points.

Individual techniques shall be classified into families according to 5.2 to 5.9 where the different renovation technique families are defined and their respective features, including materials, applications, as well as geometric, performance and installation characteristics, are described.



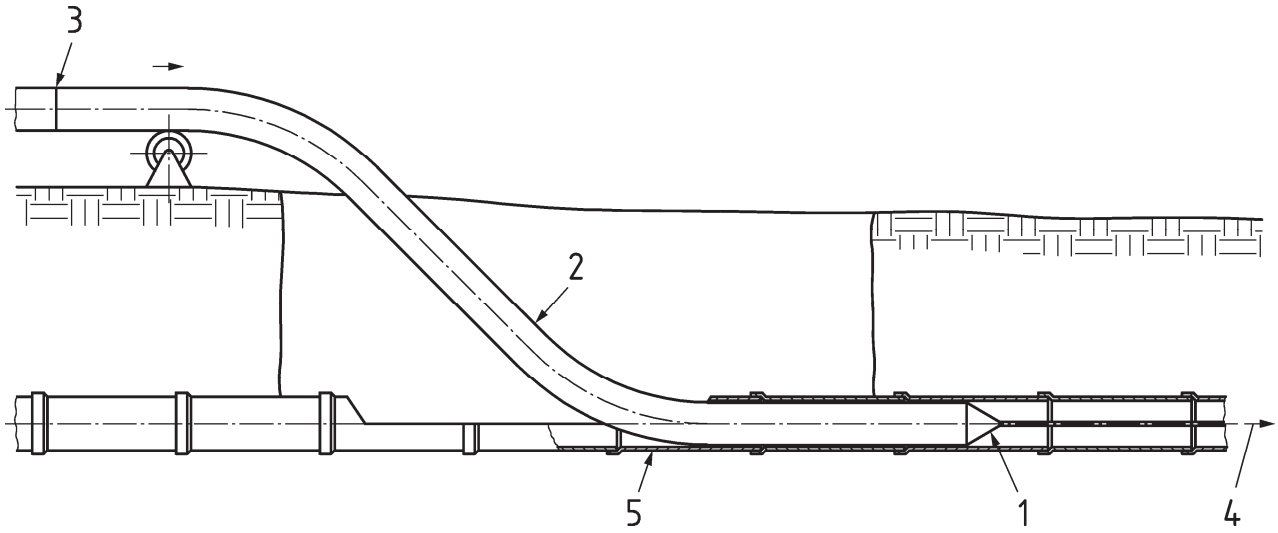
a Outside the scope of this European Standard.

b Other renovation techniques, which do not fit into the above families, are outside the scope of this European Standard which covers only technique families commonly available at the time of drafting.

Figure 1 — Renovation technique families

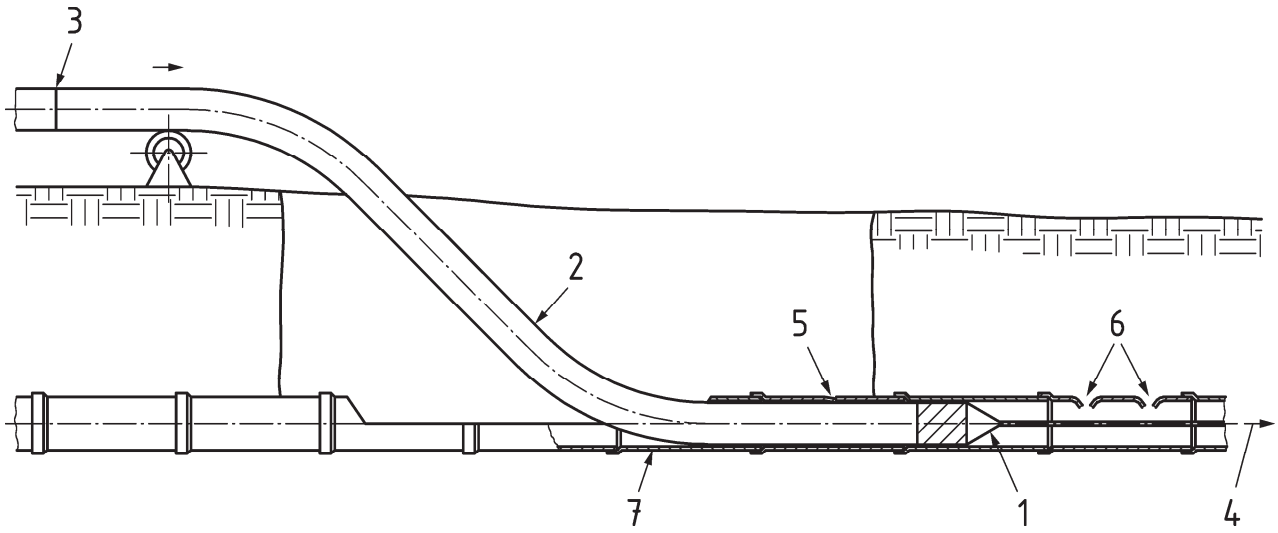
5.2 Lining with continuous pipes

Lining with pipe made continuous, typically by butt-fusion, prior to insertion, where the cross section of the pipe used for lining remains unchanged. Two possible methods of lining with continuous pipes are shown in Figure 2 and Table 1. Method B of this technique re-rounds the existing pipeline just ahead of insertion of the lining pipe in order to maximise cross section and reduce average annular gap.



Key
1 pulling head 2 lining pipe 3 prior jointing of lining pipe 4 pulling force 5 existing pipe

a) Schematic representation of lining with continuous pipes without re-rounding of existing pipeline (Method A)



Key
1 pulling and re-rounding head (only for Method B) 2 lining pipe 3 prior jointing of lining pipe 4 pulling force 5 re-rounded defect 6 defects 7 existing pipe

b) Schematic representation of lining with continuous pipes with re-rounding of existing pipeline (Method B)

Figure 2 — Lining with continuous pipes

Table 1 — Features of lining with continuous pipes

Feature	Description
Relevant standards:	EN 13566-1 and EN 13566-2
Materials:	plastics (PE, PP)
Applications:	– non pressure pipes; – pressure pipes
Geometric characteristics:	– non circular cross section possible for Method A; – typical minimum size: 100 mm for Method A, 150 mm for Method B; – typical maximum size: 1 200 mm for Method A, 600 mm for Method B; – typical maximum length: 300 m for Method A, 100 m for Method B; – some Method A techniques capable of accommodating bends
Performance:	– significant reduction in hydraulic (volumetric and flow) capacity for Method A; minimal reduction of volumetric capacity with increase in flow due to reduced friction possible for Method B; – uniform gradient cannot be restored; – structural rehabilitation is possible; – abrasion resistance depends on material; – chemical resistance depends on material
Installation characteristics:	a) pipes manufactured or prior assembled into the continuous length required; for Method B pipes of non standard outside diameter required (max. 10 mm less than host pipe inside diameter); b) insertion possible by pushing and/or pulling for Method A; for Method B only by pulling with use of re-rounding head; c) surface working space: storage of the whole insertion length required on surface: 1) small diameters (typically ≤ 180 mm) can be supplied on coils, small space; 2) larger diameters: supplied in straight lengths requiring greater storage and working space; d) access to the existing pipeline: generally requires local excavation; e) technique does not rely on adhesion to host pipe; f) flow diversion is typically required for installation; g) the annular space is typically grouted for Method A but not applicable to Method B; h) reconnection of laterals: generally requires excavation for Method A except in man entry sizes; for Method B reconnection from inside possible

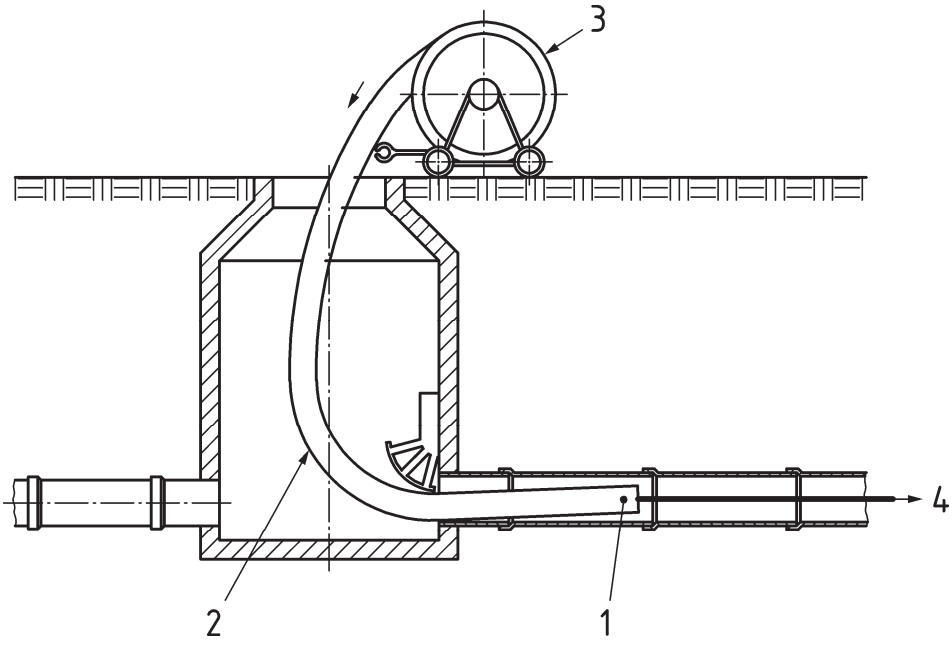
5.3 Lining with close-fit pipes

Lining with a continuous pipe for which the cross section is reduced to facilitate installation and reverted after installation to provide a close fit to the existing pipe.

Two possible methods of lining with close fit pipes are shown in Figure 3 and Table 2:

– Method A: reduction in the pipe manufacturing plant; the pipe is usually supplied coiled on a reel from which it is directly inserted;

– Method B: reduction on site (typically applied to pressure pipelines only); the pipe is fed through diameter reduction or folding equipment and simultaneously inserted.

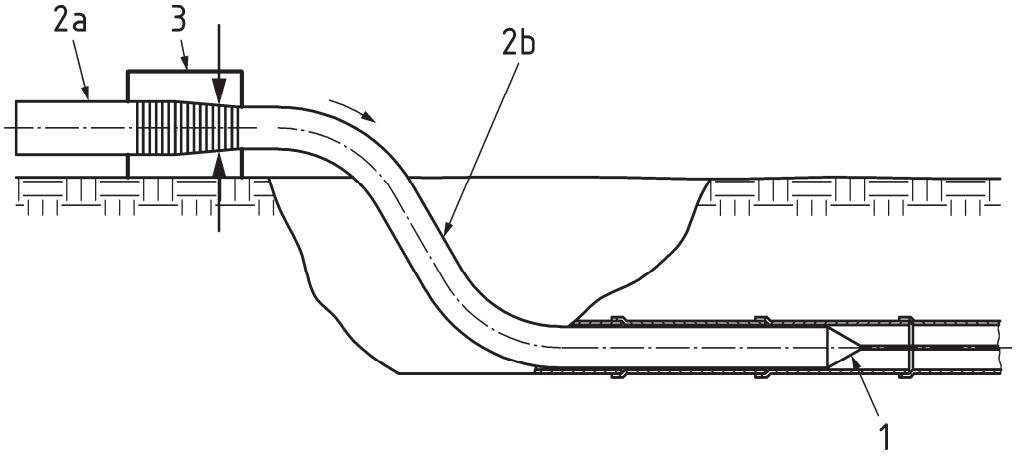


Key

1 pulling head
2 lining pipe (folded)
3 drum trailer
4 pulling line

NOTE Pipe reverted (unfolded) after insertion by application of heat and/or pressure.

a) Schematic representation of installation of a pipe reduced in cross section in the pipe manufacturing plant (Method A)



Key

1 pulling head
2a initial lining pipe
2b reduced lining pipe
3 cross section reducing device

NOTE Pipe reverted (expanded) after insertion by release of pulling force and application of pressure.

b) Schematic representation of installation of a pipe reduced in cross section on site (Method B)

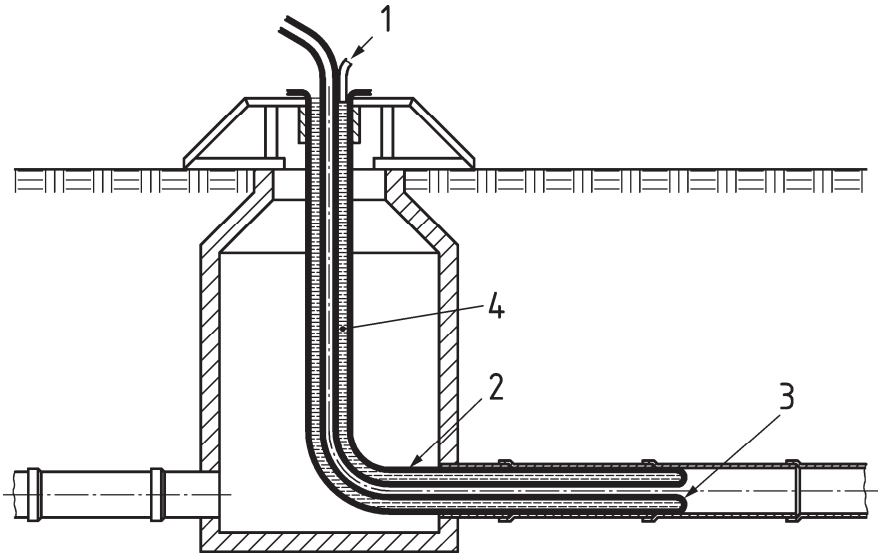
Figure 3 — Lining with close-fit pipes

Table 2 — Features of lining with close fit pipes

Feature	Description
Relevant standards:	EN 13566-1 and EN 13566-3
Materials:	plastics only (PE, PVC-U)
Applications:	– non pressure pipes; – pressure pipes
Geometric capabilities:	– some deviation from nominally circular shape possible; typical minimum size: 100 mm for Method A, 200 mm for Method B; – typical maximum size: 500 mm for Method A, 1 500 mm for Method B; – typical maximum length: 500 m; – some techniques are capable of accommodating bends
Performance:	– minimal reduction in volumetric capacity; increase in flow due to reduced friction possible; – gradient cannot be restored; – structural rehabilitation is possible; – abrasion resistance depends on material; – chemical resistance depends on material
Installation characteristics:	a) lining pipe first reduced in size by mechanical or thermo-mechanical means (in the manufacturing plant or on site), inserted and then reverted by relief of installation forces or application of heat and/or pressure; b) surface working space: no particular constraint for Method A, storage of the whole insertion length required on surface for Method B; c) access: typically through manhole for Method A, requires local excavation for Method B; d) technique does not rely on adhesion to host pipe; e) flow diversion is required; f) grouting not applicable; g) reconnection of laterals: 1) gravity pipelines: possible from inside (re-opening and tight connection); 2) in pressure applications: generally requires excavation, except in man entry sizes

5.4 Lining with cured-in-place pipes

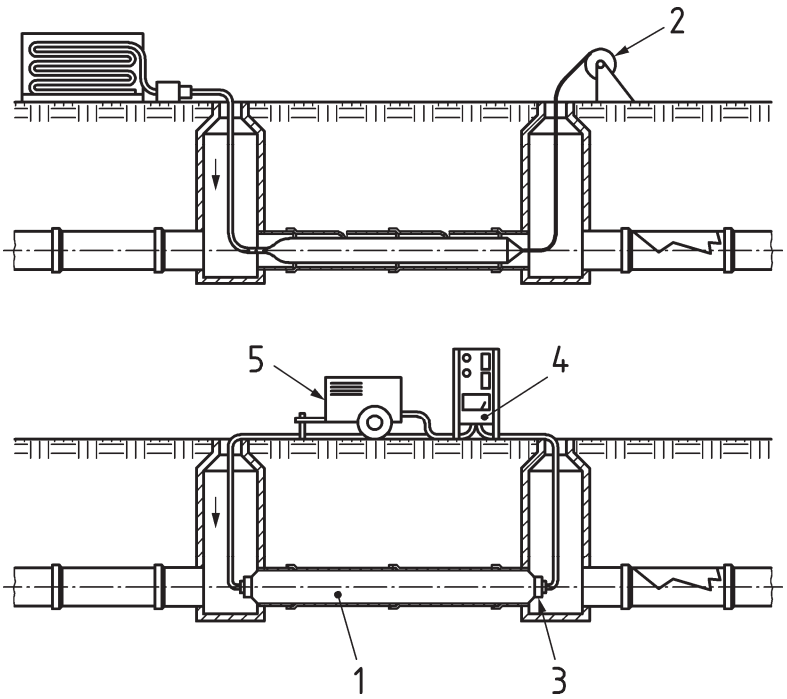
Lining with a flexible tube impregnated with a thermosetting resin which produces a pipe after resin cure (see Figure 4 and Table 3).



Key

1 applied air or water pressure for inversion
2 lining pipe
3 inversion face
4 water or air for inversion

a) Schematic representation of lining with cured-in-place pipes installed by inversion (Method A)



Key

1 lining pipe
2 winch
3 end packer
4 curing equipment
5 compressor

b) Schematic representation of lining with cured-in-place pipes installed by winching and subsequent inflation (Method B)

Figure 4 — Lining with cured-in-place pipes

Table 3 — Features of lining with cured-in-place pipes

Feature	Description
Relevant standards:	EN 13566-1 and EN 13566-4
Materials:	A composite consisting of a reinforced or unreinforced fabric carrier material impregnated with thermosetting resin (UP, EP or VE), which can include optional internal and/or external membranes. For details, see the relevant standard.
Applications:	– non pressure pipes; – pressure pipes; – technique is applicable for manholes
Geometric capabilities:	– circular and non circular cross section; – typical minimum size: 100 mm; – typical maximum size: 2 800 mm; – typical maximum length: Method A: 600 m, Method B: 250 m; – bends can be accommodated
Performance:	– minimal reduction in volumetric capacity; increase in flow due to reduced friction possible; – restoring of invert is not possible; – structural rehabilitation is possible; – abrasion resistance depends on wall structure; – chemical resistance mainly depends on resin type
Installation characteristics:	a) insertion of the impregnated tube, prior to curing, can be achieved by: 1) inverting into position with fluid pressure only (water or air) or 2) winching into place and then inflating; 3) combinations of Methods a) and b) are also possible; b) the curing process can be initiated or accelerated by either: 1) heat (hot water, steam or electrical heating elements); UV radiation or 2) ambient temperature; c) surface working space: generally minimal, varies with technique; d) access: entry via existing manhole or small excavation possible; e) structural effect does not rely on adhesion to host pipe; f) flow diversion required; g) grouting of annular space not necessary; h) re-opening of laterals from inside is possible; i) reconnection of laterals: 1) gravity pipelines: possible from inside (re-opening and tight connection); 2) in pressure applications: generally requires excavation, except in man entry sizes

5.5 Lining with discrete pipes

Lining with short lengths of pipe which are jointed to form a continuous pipe one by one during insertion (see Figure 5 and Table 4). Discrete pipes can be installed by pushing (Method A), by pulling (Method B) or by individual pipe placement (Method C).

NOTE Use of a re-rounding head with as described in 5.2 is also possible for discrete pipes Method B.

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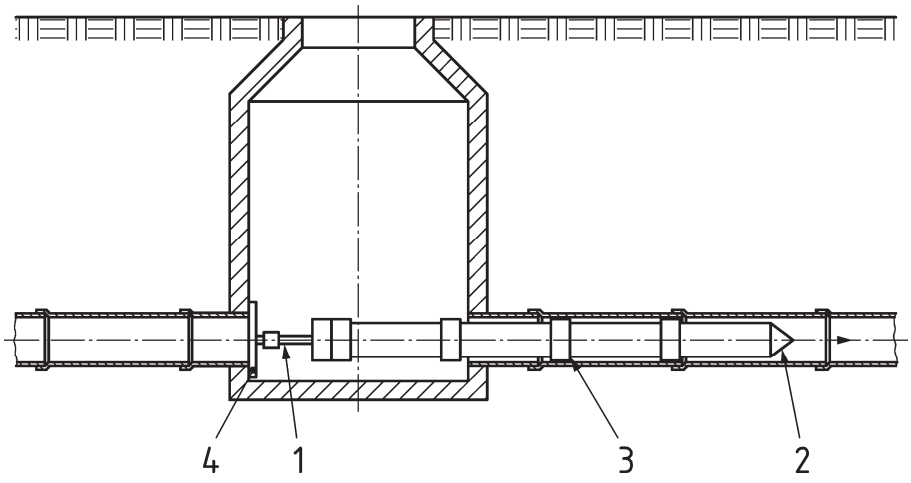
Key

1 pushing device
2 pushing guide
3 jointed lining pipe
4 thrust plate

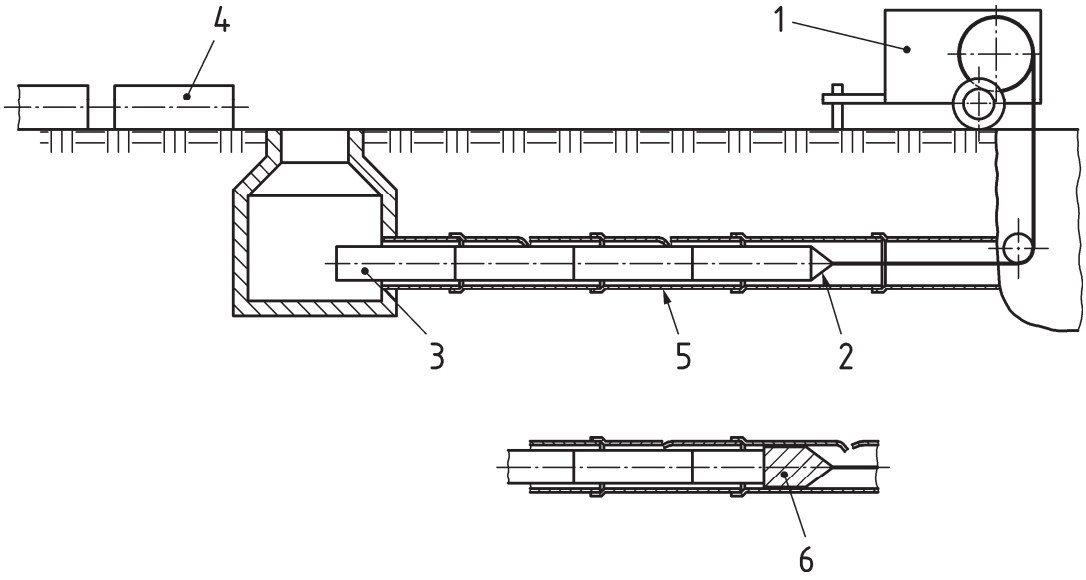


NOTE The diameter of discrete pipes for insertion is slightly reduced against the existing pipe.

a) Schematic representation of installation by pushing (Method A)

Key

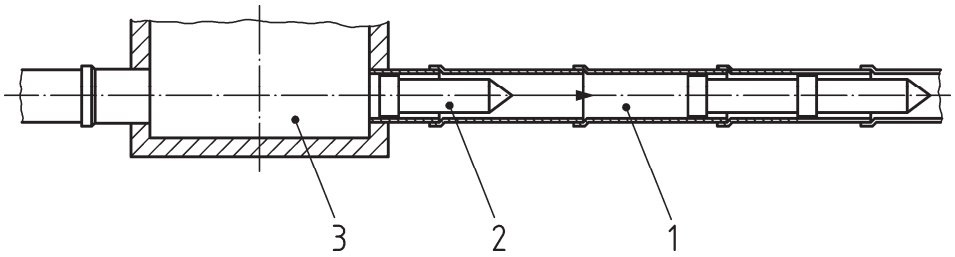
1 winch
2 pulling head
3 jointed lining pipe
4 stock of discrete pipes
5 existing pipe
6 re-rounding and pulling head



b) Schematic representation of installation by pulling (Method B)

Key

1 existing pipe
2 individual discrete pipe being pulled or pushed into place
3 manhole



c) Schematic representation of installation by individual pipe placement (Method C)

Figure 5 — Lining with discrete pipes

Table 4 — Features of lining with discrete pipes

Feature	Description
Relevant standards:	EN 13566-1
Materials:	– plastics (PE, PP, PVC-U, GRP); – metallic (steel, ductile Iron); – concrete based materials (inclusive polymer concrete), clay
Applications:	– pressure pipes; – non pressure pipes; – technique applicable for manhole renovation
Geometric capabilities:	– circular and non circular cross section; – typical minimum size: Method A and B: 100 mm; Method C: 800 mm; – typical maximum size: Method A and B: 600 mm; Method C: 4 000 mm; – typical maximum length: 150 m; – Bends: bends can generally not be accommodated for Method A and B; bends with large radii can be accommodated for Method C
Performance:	– significant reduction in hydraulic (volumetric and flow) capacity for Method A; minimal reduction of volumetric capacity for Method B where re-rounding head is used, with increase in flow due to reduced friction possible; for Method C, reduction in capacity dependent on annular space and diameter/thickness ratio; – uniform gradient can be restored using Method C in man-entry pipes; – structural rehabilitation is possible; – abrasion resistance depends on material; – chemical resistance depends on material
Installation characteristics:	– the type of joint is a significant feature of each technique; – pipe joints can be locked (end load bearing) or unlocked; – surface working space: no particular constraint; – short pipe lengths may allow insertion from existing manholes (Methods A and B); – access to the existing pipeline: generally through manholes but requires local excavation for man entry sizes; – technique does not rely on adhesion on host pipe; – flow diversion is typically required for installation and grouting; – the annular space is typically grouted, except for Method B when re-rounding and non standard lining pipe outside diameter is used (see 5.2); – reconnection of laterals: generally requires excavation; except in man entry sizes; for Method B, when a re-rounding head is used, reconnection from inside possible

5.6 Lining with spirally-wound pipes

Lining with a profiled strip, spirally wound to form a continuous pipe after installation (see Figure 6 and Table 5). This technique family does not rely on any contribution from grout for its structural performance.

NOTE For this technique the continuous pipe after installation is the structural element, with minimum ring stiffness conforming to EN 13566-1.

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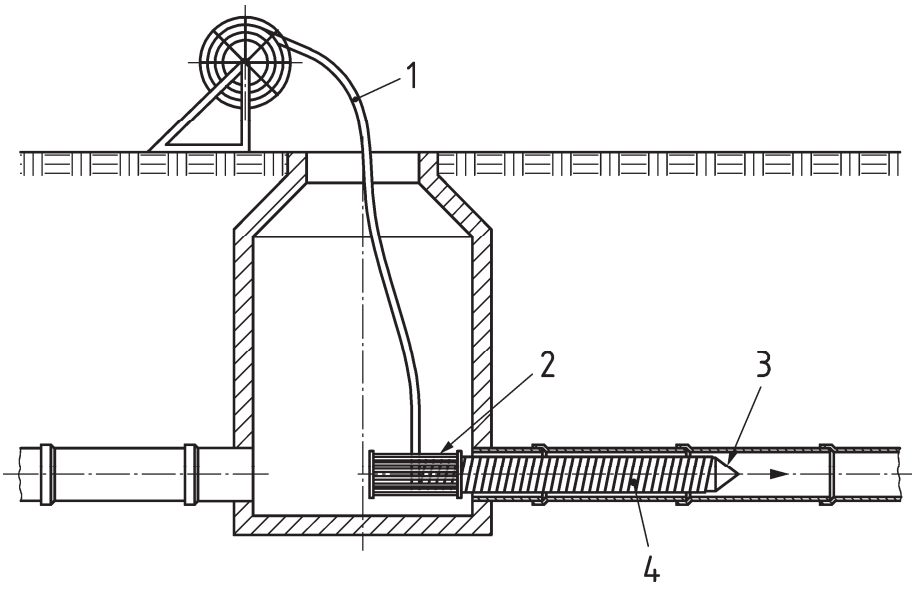
Key

1 plastics strip to be spirally wound

2 winding machine in the manhole

3 guidance head (where applicable)

4 spirally-wound lining pipe



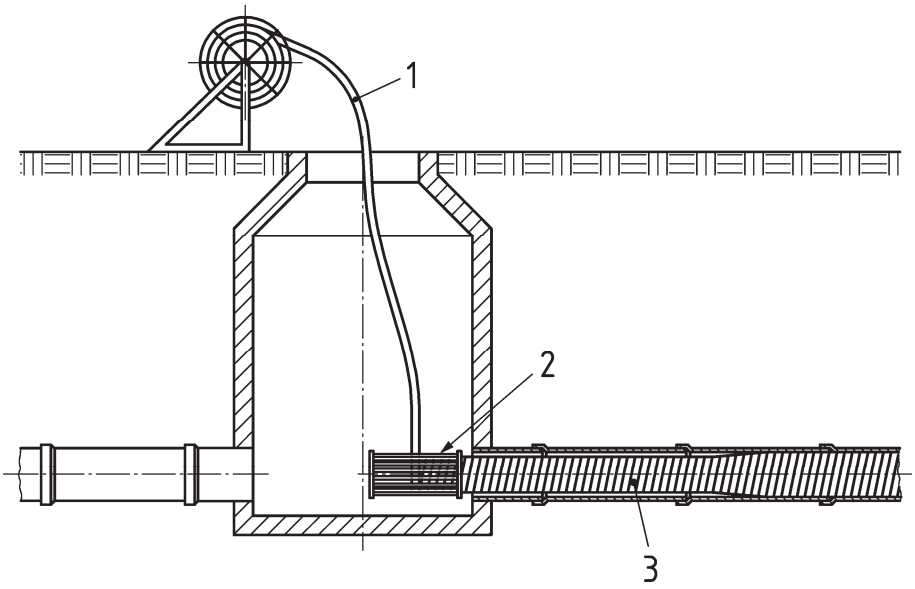
a) Schematic representation of fixed diameter winding from the manhole (Method A1)

Key

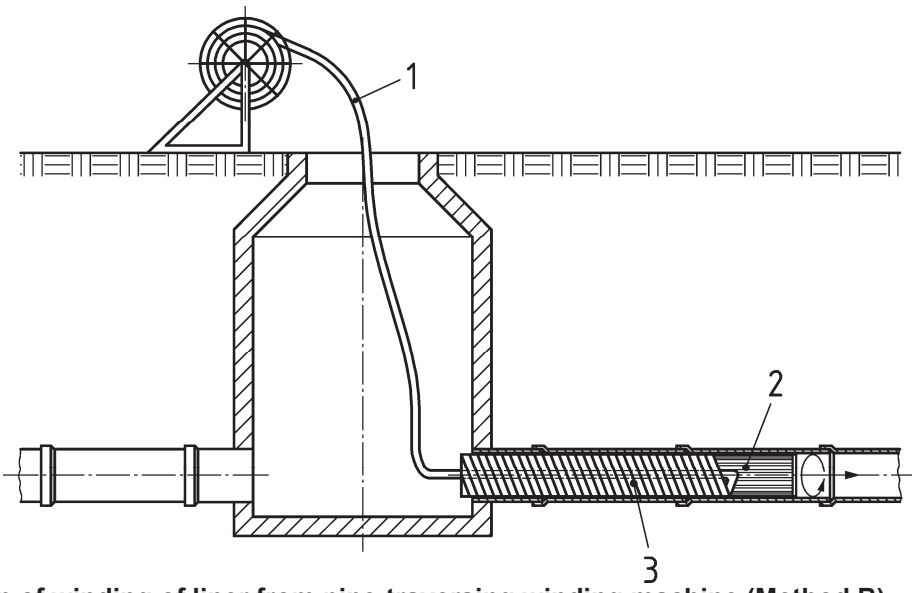
1 plastic strip to be spirally wound

2 winding machine in the manhole

3 spirally-wound lining pipe temporarily locked at reduced diameter for insertion



b) Schematic representation of expanded liner winding from the manhole (Method A2)



Key

1 plastics strip to be spirally wound

2 winding machine in the pipe

3 spirally-wound liner

c) Schematic representation of winding of liner from pipe-traversing winding machine (Method B)

Figure 6 — Lining with spirally-wound pipes

Table 5 — Features of lining with spirally-wound pipes

Feature	Description
Relevant standards:	EN 13566-1 and EN 13566-7
Materials:	plastics (PVC-U, PE), optional steel reinforcement
Applications:	– non pressure; – applicable for manholes
Geometric capabilities	– circular cross section; – typical minimum size: 200 mm for Method A1 and Method A2; 800 mm for Method B; – typical maximum size (without steel reinforcement): 1 200 mm for Method A1, 700 mm for Method A2, 1 800 mm for Method B; [a] – typical maximum length: 100 m; – bends can be accommodated
Performance:	– reduction in capacity dependent on annular space and ratio of diameter to overall profile height; – uniform gradient can generally not be restored; – structural renovation is possible; – abrasion resistance depends on material; – chemical resistance depends on material;
Installation characteristics:	– lining pipe formed on site by spirally winding a strip, which is jointed and sealed by solvent welding or mechanical means; – individual winding machines can produce a range of diameters; – no pipe storage on site; – access via manholes possible; – technique does not rely on adhesion to host pipe; – flow diversion during installation is typically required for grouting and installation; – grouting of annular space is required for fixed diameter; – for (re)connection of laterals in non man entry pipes local excavation is generally required; reconnection from the inside is also possible

[a] Larger sizes are possible with steel reinforcement.

5.7 Lining with a rigidly anchored inner plastics layer

Lining with a single rigid annulus of structural cementitious grout formed behind an inner plastics layer with integral profiles or studs permanently anchored to the grout (see Figure 7 and Table 6). This technique family relies on the rigid annulus of grout for its structural performance.

Key

1 inner plastics layer with integral profiles or studs for anchorage

2 grout with optional reinforcement

3 external layer if applicable

4 existing pipe (host pipe)

5 anchors

[a] detail of wall construction

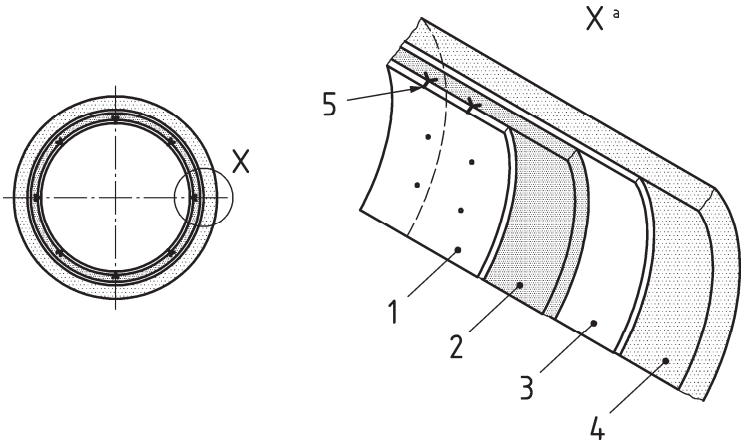


Figure 7 — Typical wall construction of a lining system with inner plastics layer rigidly anchored in structural cementitious grout

Several different types of internal plastics layer introduced by different techniques are in use. In addition to tubes of studded plastics sheeting winched in place and inflated prior to grouting, these include discrete pipes of plastics materials installed according to 5.5, spirally-wound pipes according to 5.6 and full pipe segments of plastics materials according to 5.8, where structural performance depends on permanent anchorage of the plastics component to a rigid annulus of cementitious grout.

Table 6 — Features of lining with a rigidly anchored inner plastics layer

Feature	Description
Relevant standards:	in preparation
Materials:	structural cementitious grout with or without reinforcement plus inner layer of PE, PP or PVC-U, and optional outer plastics layer
Applications:	– non pressure pipes; – technique is applicable for manhole renovation
Geometric capabilities:	– circular and non circular cross section; – typical minimum size: 200 mm but technique dependent; – typical maximum size: 2 000 mm; [a] – typical maximum length: 200 m; – bends accommodated
Performance:	– reduction in capacity dependent on annular space and ratio of diameter to overall profile height; – uniform gradient can generally not be restored; – structural renovation is possible (depending on the strength of the grout); – inner plastics layer material determines abrasion resistance; – mechanically anchored inner plastics layer determines chemical resistance
Installation characteristics:	– surface working space is generally minimal; – access is generally possible via manholes; – technique does not rely on adhesion to host pipe; – typically requires flow diversion and absence of groundwater infiltration; – grouting of annular space integral part of this technique; – reconnection of laterals is possible from inside, if outer plastics layer used

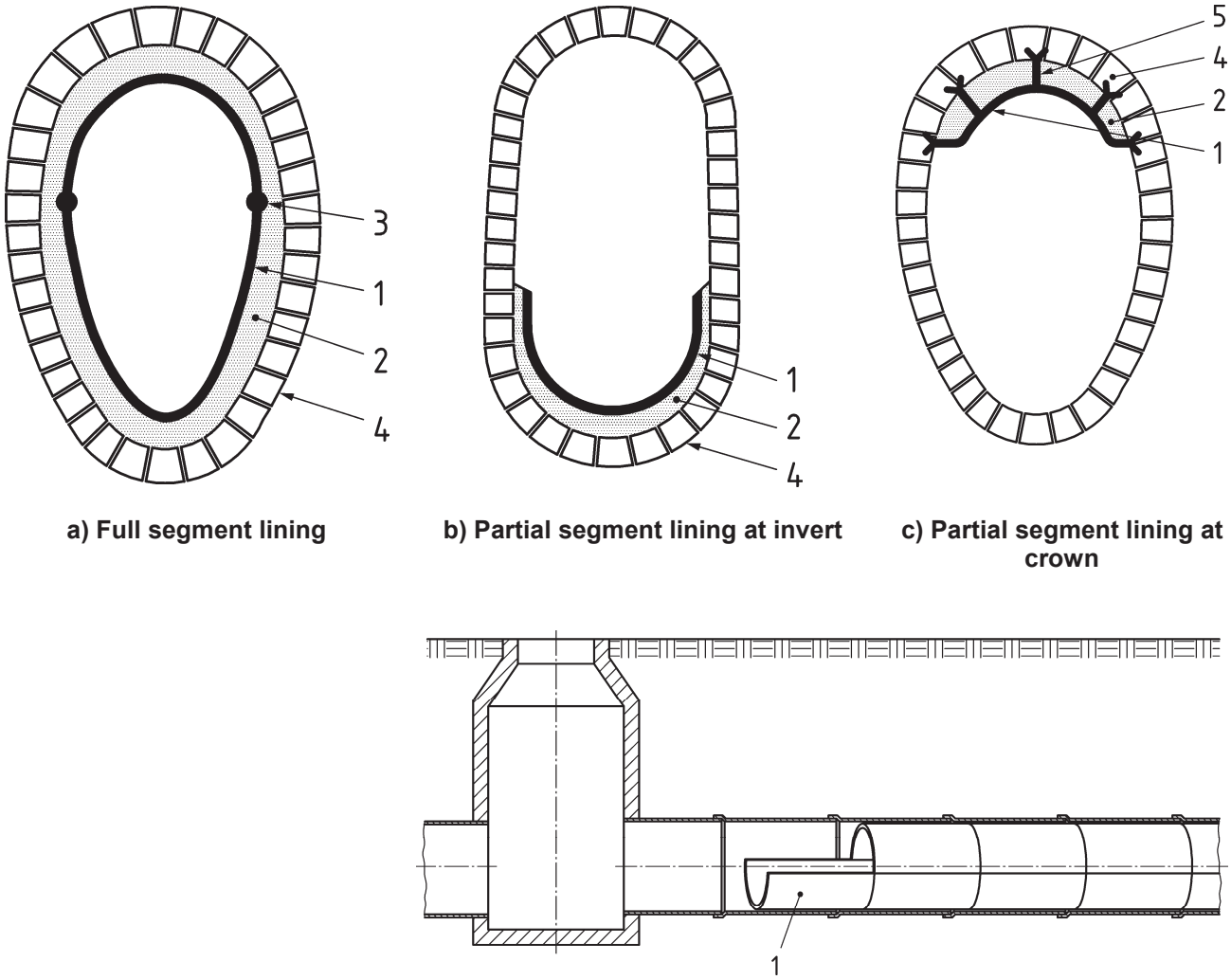
[a] Sizes up to 5 000 mm are possible with certain specialised techniques and materials.

5.8 Lining with pipe segments

Lining with prefabricated segments bonded to the existing pipe (see Figure 8 and Table 7), which either:

a) have longitudinal joints and cover the whole of the pipe circumference, or

b) cover only part of circumference.



a) Full segment lining **b) Partial segment lining at invert** **c) Partial segment lining at crown**

d) Schematic representation of lining with pipe segments

Key
1 lining pipe segments
2 grout
3 longitudinal joints
4 existing pipe
5 anchors

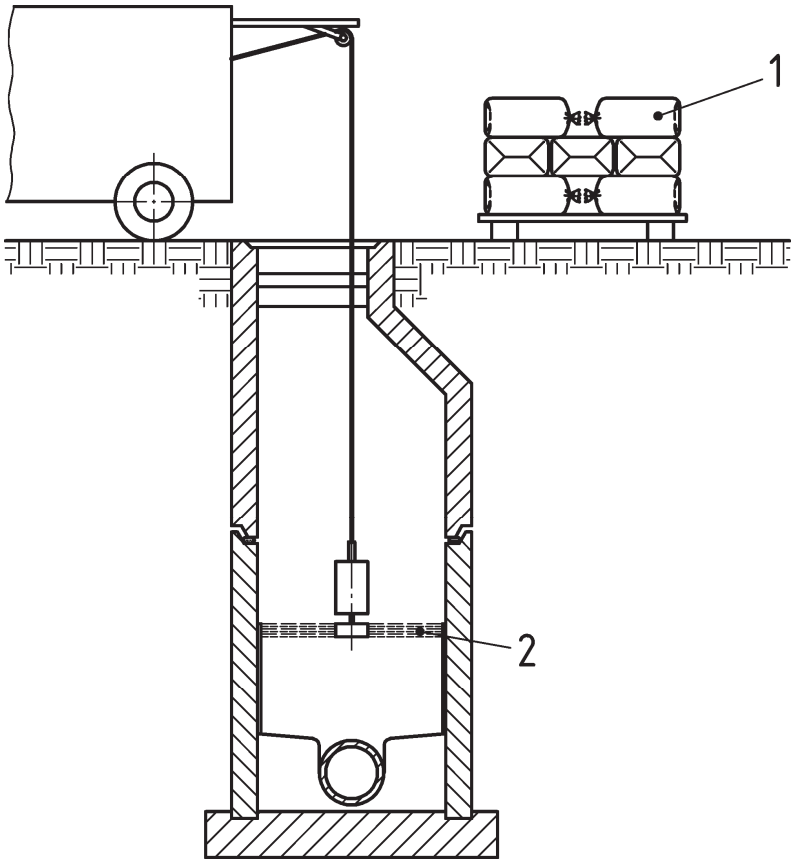
Figure 8 — Full and partial lining with pipe segments

Table 7 — Features of full and partial lining with pipe segments

Feature	Description
Relevant standards:	none
Materials:	plastics (PVC-U, PE, PP, GRP), GRC, PCC, clay, ductile iron, concrete, fused basalt
Applications:	– non pressure pipes; – technique applicable for manholes
Geometric capabilities:	– circular and non circular cross section; – typical minimum size: man-entry sewer only; – typical maximum size: no limit; – maximum length: no limit; – bends can be accommodated
Performance:	a) hydraulic performance: 1) full segment lining: reduction in capacity dependent on annular space and thickness in relation to diameter; uniform gradient can be restored; 2) partial segment lining at invert: can improve open channel flow; uniform gradient can be restored; 3) partial segment lining at crown: effect on hydraulic performance only where the pipe runs full; b) structural enhancement: 1) full segment lining: structural renovation is possible; 2) partial segment lining at invert: no significant improvement; 3) partial segment lining at crown: crown stability can be improved; c) abrasion and chemical resistance: 1) full segment lining and partial lining at invert: liner pipe material determines abrasion and chemical resistance; 2) partial segment lining at crown: liner pipe material determines chemical resistance; no effect on abrasion resistance
Installation characteristics:	– jointing typically by either mechanical interlock or welding; – lining pipe segments prefabricated or shaped in place; – mechanical link to host pipe using grouting, gluing and/or anchoring is required; – surface working space minimal at access point, but site storage for segments required; – access via manholes is possible; – partial segment lining techniques rely on adhesion to host pipe; – flow diversion dependent on safety requirements due to man entry; – grouting of annular space is required; – reconnection of laterals is possible from inside

5.9 Lining with sprayed material

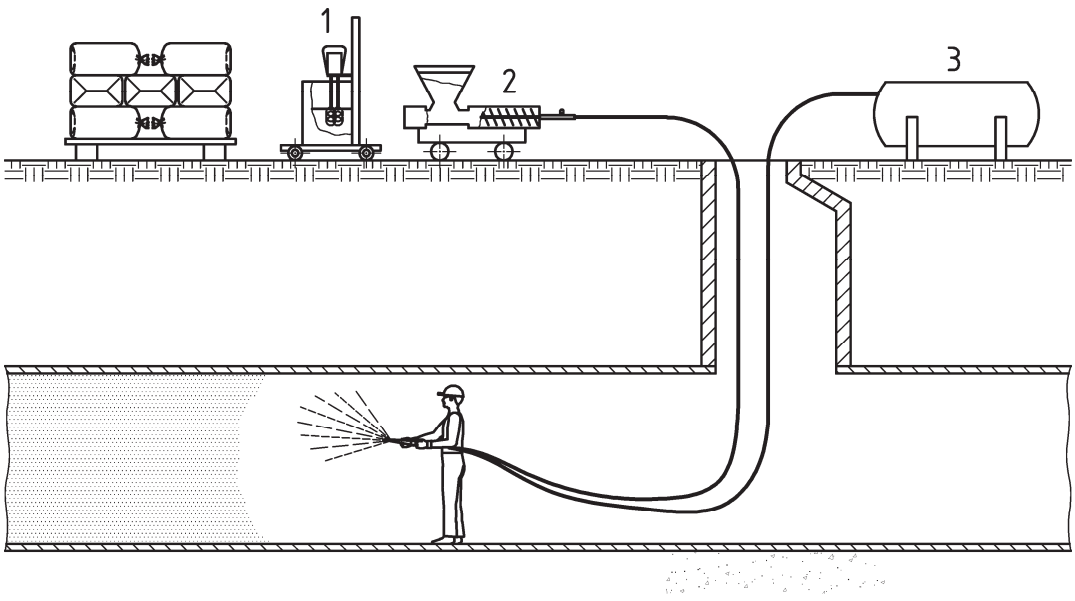
Lining by applying cementitious or polymeric mortar, with or without prior placement of reinforcement, directly onto the inside surface of the host pipe and/or manhole, by manual or mechanical, including robotic, means. (see Figure 9 and Table 8).



Key

1 mortar packages
2 application of mortar

a) Schematic representation of sprayed of mortar applied by mechanical means (here in manhole)



Key

1 mixing machine
2 pump
3 compressor

b) Schematic representation of sprayed concrete applied by hand

Figure 9 — Examples of lining with sprayed material

Table 8 — Features of lining with sprayed material

Feature	Description
Relevant standards:	none
Materials:	cementitious and polymeric mortars; sprayed mortar can be reinforced with pre-placed steel; reinforcing fibres can also be incorporated in sprayed mortars
Applications:	– non pressure and pressure pipes; – techniques using mortar generally applicable to manholes
Geometric capabilities:	a) circular and non circular cross section; b) typical minimum size: 1) by mechanical means: 200 mm 2) by hand: technique dependent but at least 800 mm; c) typical maximum size : 1) by mechanical means: 3 500 mm 2) by hand: no limit; d) typical maximum length: 1) by mechanical means: 100 m 2) by hand: limited by safety considerations; e) bends can be accommodated
Performance:	– improvement of flow is possibly dependent on thickness of liner relative to diameter and liner surface finish; – uniform gradient can generally be restored; – structural renovation is possible using sprayed cement mortar; – liner material determines abrasion and chemical resistance
Installation characteristics:	– either full or partial section; – surface of cementitious liners can be trowelled by hand or mechanical means, where this improves finish; – hand spraying requires sufficient working space to avoid spray-back of material and sufficient height for operative to stand upright; – wall thickness to meet design requirements limited by material characteristics; – surface working space: minimal; – access via manholes is possible; – relies on mechanical or chemical bond to existing pipe or manhole surface which requires specific preparation; – flow diversion is typically required for pipe renovation; – lateral connections should be protected from being covered by applied material and made good as part of final finish

6 Classification of repair techniques for drains and sewers

6.1 General

Repair technique families within the scope of this European Standard are shown in Figure 10. This clause establishes a classification of repair techniques into families, where repair is applied to rectify local defects in drains, sewers and/or associated manholes. Individual techniques shall be classified into families according to 6.2 to 6.6 where the different repair technique families are defined and their respective features, including materials, applications, as well as geometric, performance and installation characteristics, are described.

All repair techniques require at least local cleaning prior to installation; attention is drawn in Tables 9 to 13 to any additional surface preparation needed.

Attention is drawn to any legislation relating to the environmental impact.

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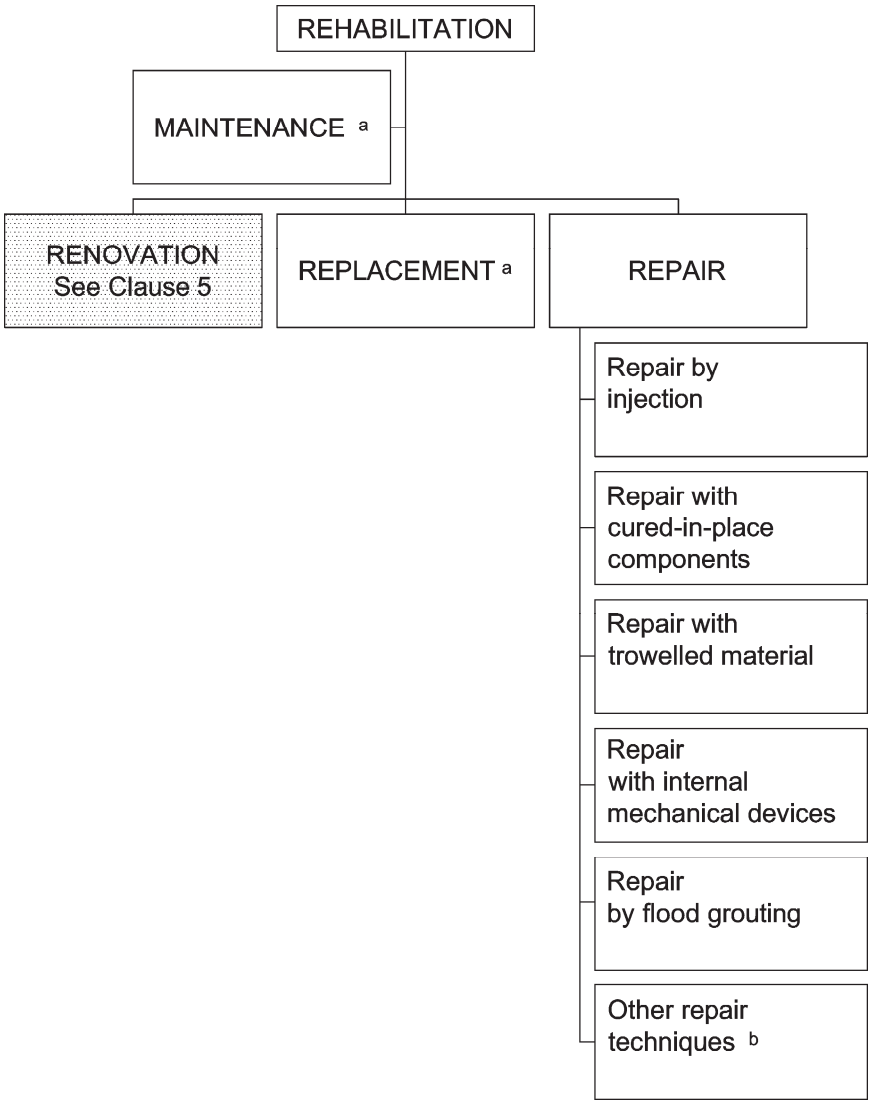


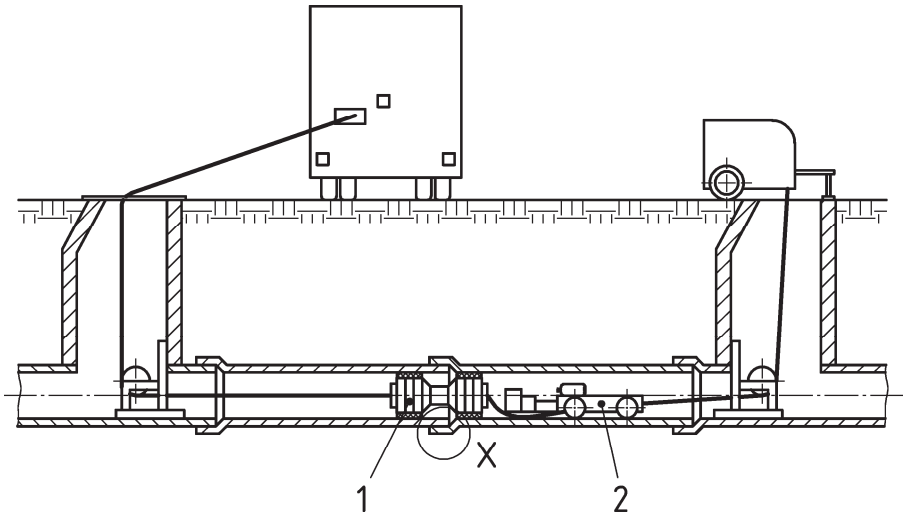
[a] Outside the scope of this European Standard.

[b] Other repair techniques, which do not fit into the above families, are outside the scope of this European Standard which covers only technique families commonly available at the time of drafting.

Figure 10 — Repair technique families

6.2 Repair by injection

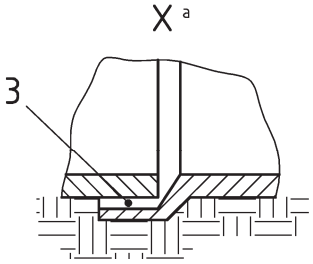
Schematic representations are shown in Figure 11 and Figure 12. Features are described in Table 9.



Key

1 packer
2 CCTV camera
3 defective joint to be filled/repaired

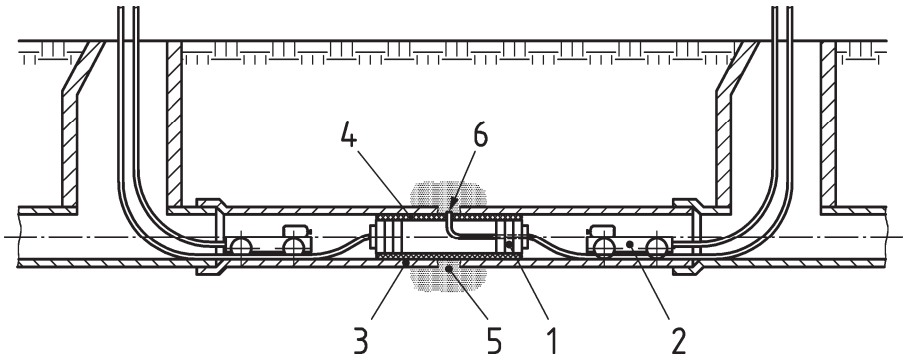
[a] joint



a) Repair of main pipe defect using gel (example of leaking joint)

Key

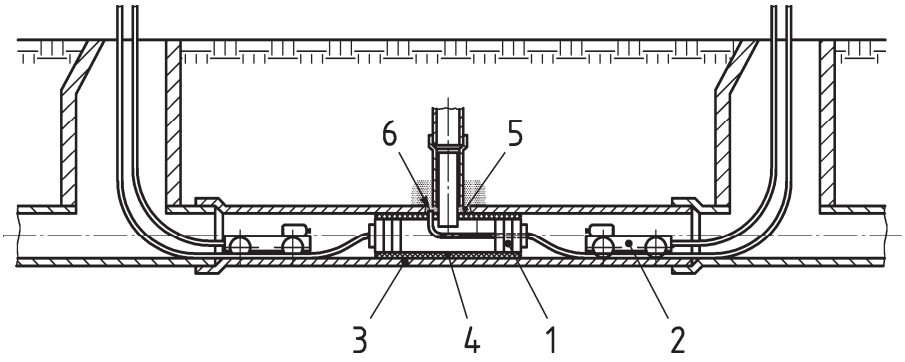
1 packer
2 CCTV camera
3 existing pipe
4 packer skin
5 injected void
6 opening for injection



b) Repair of main pipe with resin or cementitious grout

Key

1 packer
2 CCTV camera
3 existing pipe
4 packer skin
5 injected void
6 opening for injection



c) Repair of lateral connection

Figure 11 — Injection by robotic means

Key

1 point of injection
2 filled void

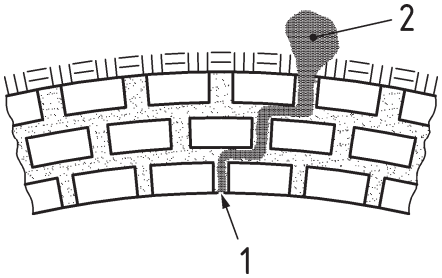


Figure 12 — Injection grouting (man-entry sewers)

Table 9 — Features for injection

Feature	non man entry	man entry
Relevant standards:	none	none
Materials:	gels (acrylic, PUR, silicate), resins (PUR, silicate), cement mortar	gels (acrylic, PUR, silicate), resins (PUR, EP, silicate), cement mortar
Application:	non pressure networks only; a) joints, b) local damage to pipes, c) lateral connections	non pressure networks only; a) joints, b) local damage to pipes, c) lateral connections, d) manholes
Geometric capabilities	– circular and non circular cross section; – typical minimum size of main pipe: 150 mm; – typical maximum size of main pipe: 750 mm; – lateral connection: Main pipe min. 200 mm (lined main pipe 175 mm) and lateral min. 100 mm to 250 mm	– circular and non circular cross section; – typical minimum size 800 mm [a]; – no limit on the upper size; – bends can be accommodated

Table 9 *(continued)*

Feature	non man entry	man entry
Performance:	– repairs using gel have limited resistance to surcharge pressure in gravity systems; – repairs using gel are non stabilising, repairs using resins or cementitious grout can be stabilising; – repair resists external water pressure; – no adhesion to host pipe required (for gel systems only); – no reduction in hydraulic capacity; – gel can fill voids at joints only and needs a permanently humid environment to maintain its sealing effect; – resins and cementitious grout can repair joints, cracks and/or lateral connections, regardless of long term humidity; – all injection materials can fill voids in the soil depending on the size of the void; – technique does not improve the abrasion resistance; – technique does not improve the chemical resistance	– repairs using gel have limited resistance to surcharge pressure in gravity systems; – repairs using gel are non stabilising, repairs using resins or cementitious grout can be stabilising; – repair resists external water pressure; – no adhesion to host pipe required (for gel systems only); – no reduction in hydraulic capacity; – gel can fill voids at joints only and needs a permanently humid environment to maintain its sealing effect; – resins and cementitious grout can repair joints, cracks and/or lateral connections, regardless of long term humidity; – all injection materials can fill voids in the soil depending on the size of the void; – technique does not improve the abrasion resistance; – technique does not improve the chemical resistance
Installation characteristics	a) applied by robots and packers under CCTV control; b) surface working space minimal; c) access through manholes is possible; d) flow diversion generally required for installation; e) installation against running ground water possible with gels, PUR and silicate resins; with cementitious materials limited by severity of infiltration; f) typical limits on working distance from access point: 1) 200 m for gels, 2) 150 m for resins, 3) 100 m for cementitious grouts; g) holes can be made in the sewer for injection from inside, and for vents; h) spacing of injection holes to ensure continuity of void filling	a) applied by handheld tools; b) surface working space minimal; c) access through manholes is possible; d) flow diversion generally required for installation; e) limit on working distance from access point depends on safety only [a]; f) holes can be made in the sewer for injection from inside, and for vents; g) injection pressure controlled so as not to exceed sewer mechanical strength; h) spacing of injection holes to ensure continuity of void filling
[a] Attention is drawn to any national regulations applicable to safety.		

6.3 Repair with cured-in-place components

This family includes cured in place patches (short length pipe repairs) and lateral connection collars of two types (“top hat” and “tee-piece”). The material of the rim of top hat connection collars can be either cured in place, or thermoplastic fused to a compatible thermoplastic main pipe liner.

Schematic representations are shown in Figures 13 and 14. Features are described in Table 10.

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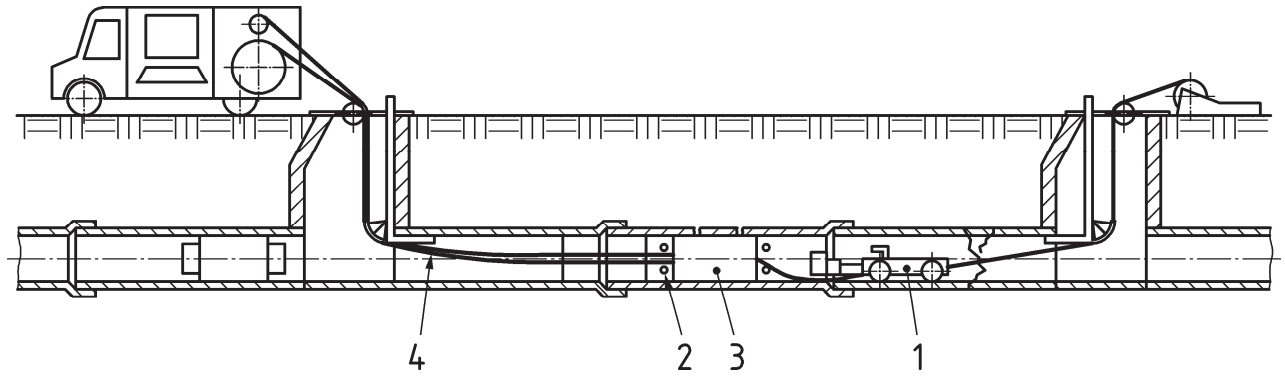
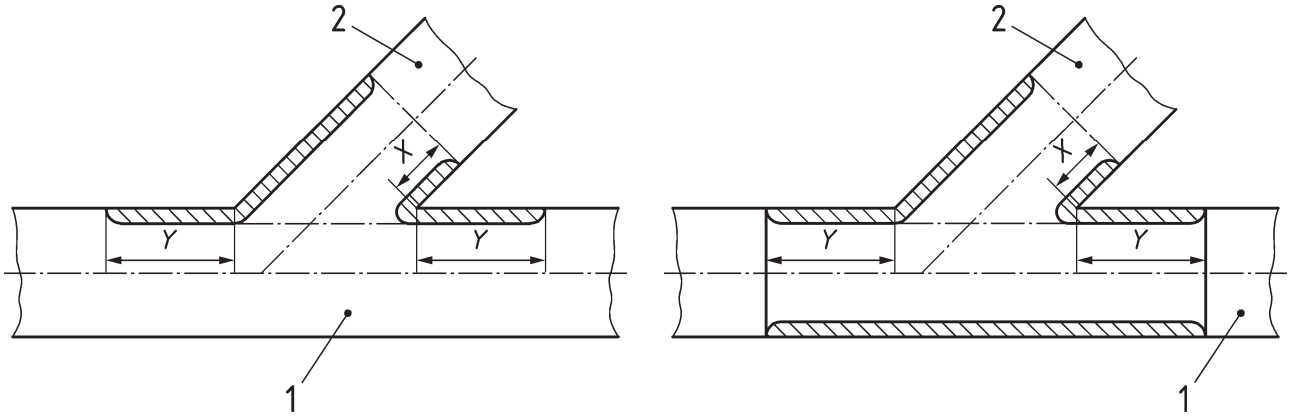


Key

1 CCTV
2 packer
3 cured in place patch
4 heating (optional) and air lines

Figure 13 — Cured–in-place patch repair



a) top hat **b) tee piece**

Key

1 main pipe
2 lateral pipe
X extension of collar
Y rim of collar

Figure 14 — Cured-in-place lateral connection collars

Table 10 — Features for cured-in-place repair

Feature	non man entry	man entry
Relevant standards:	none	none
Materials:	A composite consisting of a reinforced or non-reinforced fabric carrier material impregnated with thermosetting resin (UP, EP or silicate, VE), which may include optional internal and/or external membranes.	A composite consisting of a reinforced or non-reinforced fabric carrier material impregnated with thermosetting resin (UP, EP or silicate, VE), which may include optional internal and/or external membranes.
Application:	– non pressure pipes; – main pipe/ laterals	– non pressure pipes; – main pipe/ laterals
Geometric capabilities:	a) circular and non circular cross section; b) cured in place patches: typical minimum size: 100 mm; c) lateral connection collar (see Figure 14): 1) cured in place rim: main pipe min. 150 mm and lateral min. 100 mm 2) fused thermoplastic rim: main pipe min. 250 mm and lateral min. 100 mm	a) circular and non circular cross section; b) typical minimum size: 700 mm; c) typical maximum size: none
Performance:	– mechanical and/or leak sealing function; – repair does not usually resists internal pressure; – repair resists external water pressure;	– mechanical and/or leak sealing function; – repair does not usually resists internal pressure; – repair resists external water pressure
Installation characteristics:	– robotically applied; – bonding to host pipe via resin adhesion or thermoplastic fusion; – requires preparation of pipe surface; – method of sealing annulus at ends: not relevant (tight fitting method); – slight bends can be accommodated; – surface working space minimal; – access through manholes is possible; – some techniques allow flow-through, others generally require consideration of flow management; – no reduction in hydraulic capacity; – potential steps in invert at ends of repair can be grinded using robots; – typical limit on working distance from access point: 200 m	– bonding to host pipe via resin adhesion or thermoplastic fusion; – requires preparation of pipe surface; – method of sealing annulus at ends: not relevant (tight fitting method); – slight bends can be accommodated; – surface working space minimal; – access through manholes is possible; – some techniques allow flow-through, others generally require consideration of flow management; – no reduction in hydraulic capacity; – potential steps in invert at ends of repair can be grinded by hand; – no limit in working distance

6.4 Repair with trowelled material

A schematic representation is shown in Figure 15. Features for repair with trowelled material are described in Table 11.

Key

1 defect

2 robot with CCTV camera

3 grout feeder tube

4 injected grout filler

5 trowel

[a] detail of grout injection and trowelling procedure

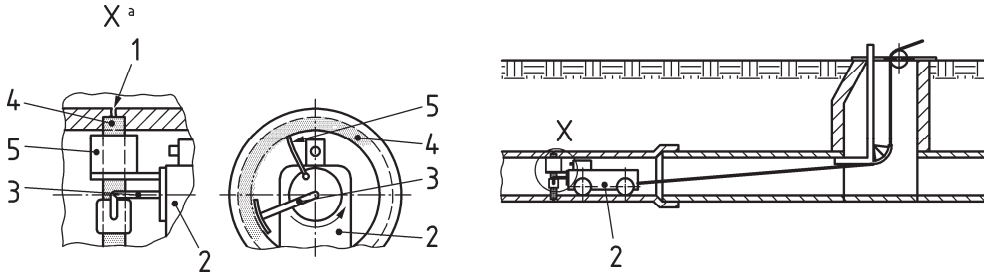


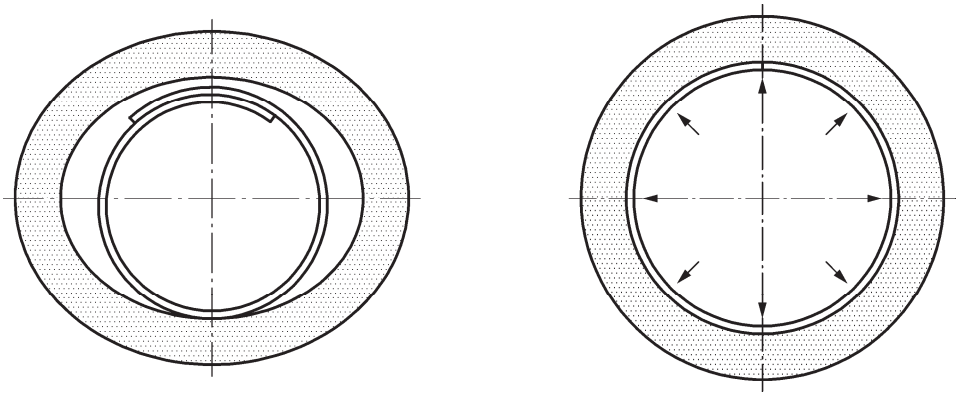
Figure 15 — Repair with trowelled material - non man entry robotic application

Table 11 — Features of repair with trowelled material

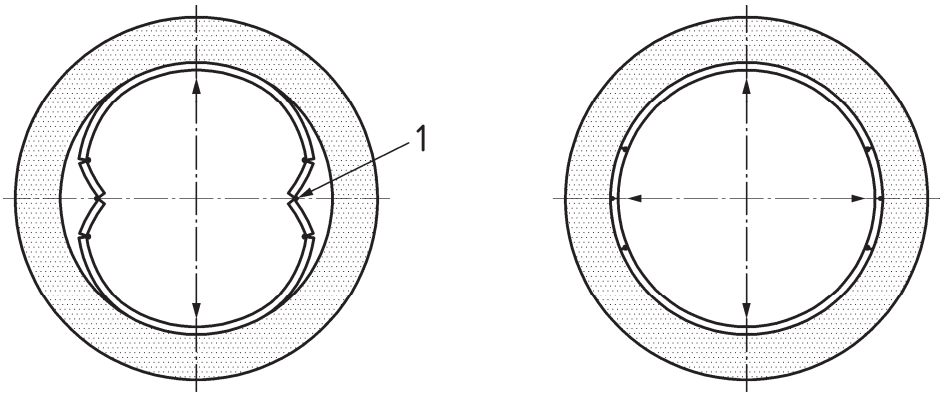
Feature	non man entry	man entry
Relevant standards:	none	none
Materials:	– EP-Resin, cementitious or polymeric mortar	– EP-Resin, cementitious or polymeric mortar with or without reinforcing fibres
Application:	– non pressure pipes; – main pipe; – can be used to repair lined pipe; – lateral connection repair: main pipe min. 200 mm and lateral 100 mm to 150 mm	– non pressure pipes; – manholes / main pipe; – can be used to repair lined pipe; – lateral connection
Geometric capabilities	– circular; – typical minimum size: 150 mm; – typical maximum size: 700 mm	– circular and non circular cross section for man entry sizes; – typical maximum size: none
Performance	– repair resists external water pressure; – repair does not resist internal pressure	– mechanical and/or hydraulic improvement; – repair does not resist internal pressure; – repair resists external water pressure
Installation characteristics	– non man-entry robotic application; – bonding to host pipe is performed via adhesion; – requires preparation of pipe surface; – method of sealing annulus at ends: not relevant; – surface working space minimal; – access through manholes is possible; – no step in invert at ends of repair; – typical limit on working distance from access point: 100m for non man entry; – generally require consideration of flow management	– manual application; – man-entry pipes hand laid / use of reinforcement only in man entry sizes improves mechanical resistance; – bonding to host pipe is performed via adhesion; – requires preparation of pipe surface; – method of sealing annulus at ends: not relevant; – bends can be accommodated; – surface working space minimal; – access through manholes is possible; – generally no reduction in hydraulic capacity; – no step in invert at ends of repair; – no limit in working distance

6.5 Repair with internal mechanical devices

Features for repair with internal mechanical devices are described in Table 12. Schematic representation of repair using internal mechanical seals and re-rounding clips is shown in Figure 16.



a) Compression ring expanded by pressurized bladder or mechanical or hydraulic tool, where designed also to achieve re-rounding, an hydraulic expander is typically used



Key

1 hinges

b) Hinged re-rounding clip expanded sequentially by vertical and horizontal jacks

Figure 16 — Schematic representation of repair using internal mechanical devices

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Table 12 — Features of repair with internal mechanical devices

Features	non man entry	man entry
Relevant standards:	none	none
Materials:	– overlap compression rings and hinged clips of stainless steel; – elastomeric ring seals typically EPDM; – resin typically EP or PUR, with or without carrier material	– overlap compression rings and hinged clips of stainless steel; – elastomeric ring seals typically EPDM
Application:	– gravity pipes only; – main pipe; – can be used to repair lined pipe	– gravity pipes; pressure pipes sealing of joints only; – main pipe; – can be used to repair lined pipe
Geometric capabilities:	– circular cross section; – typical minimum size: 150 mm; – typical maximum size: 800 mm	– circular cross section; – typical minimum size: 800mm; – typical maximum size: 3 000 mm
Performance:	– leak sealing; – re-rounding where techniques designed for that purpose; – repair resists external water pressure where seal is provided; – devices create local invert step; – reduction in hydraulic capacity generally low due to localised nature	– leak sealing; – re-rounding where techniques designed for that purpose, gravity pipes only; – joint repairs in pressure pipes designed resist internal pressure; – repair resists external water pressure; – devices create local invert step; – reduction in hydraulic capacity generally low due to localised nature
Installation characteristics:	– requires preparation of pipe surface; – anchoring within host pipe is achieve by mechanical compression with or without additional resin adhesion; – sealing achieved by compression of elastomeric rings or by resin material; – steel compression ring locked in place by mechanical or hydraulic devices or tools; – surface working space minimal; – access through manholes is possible; – some techniques allow flow-through, others generally require consideration of flow management; – typical limit on working distance from access point: 100 m	– manual application only; – requires preparation of pipe surface; – anchoring within host pipe is achieved by mechanical compression, – sealing achieved by compression of elastomeric rings; – bends: not relevant (only applied at joints); – surface working space minimal; – access through manholes is possible; – some techniques allow flow-through, others generally require consideration of flow management; – typical limit on working distance from access point: 200 m depending on working conditions

6.6 Repair by flood grouting

This repair method is used for sealing of joints in the sewer fabric and/or immediately adjacent voids in the surrounding ground. Schematic representation are shown in Figure 17, features are described in Table 13.

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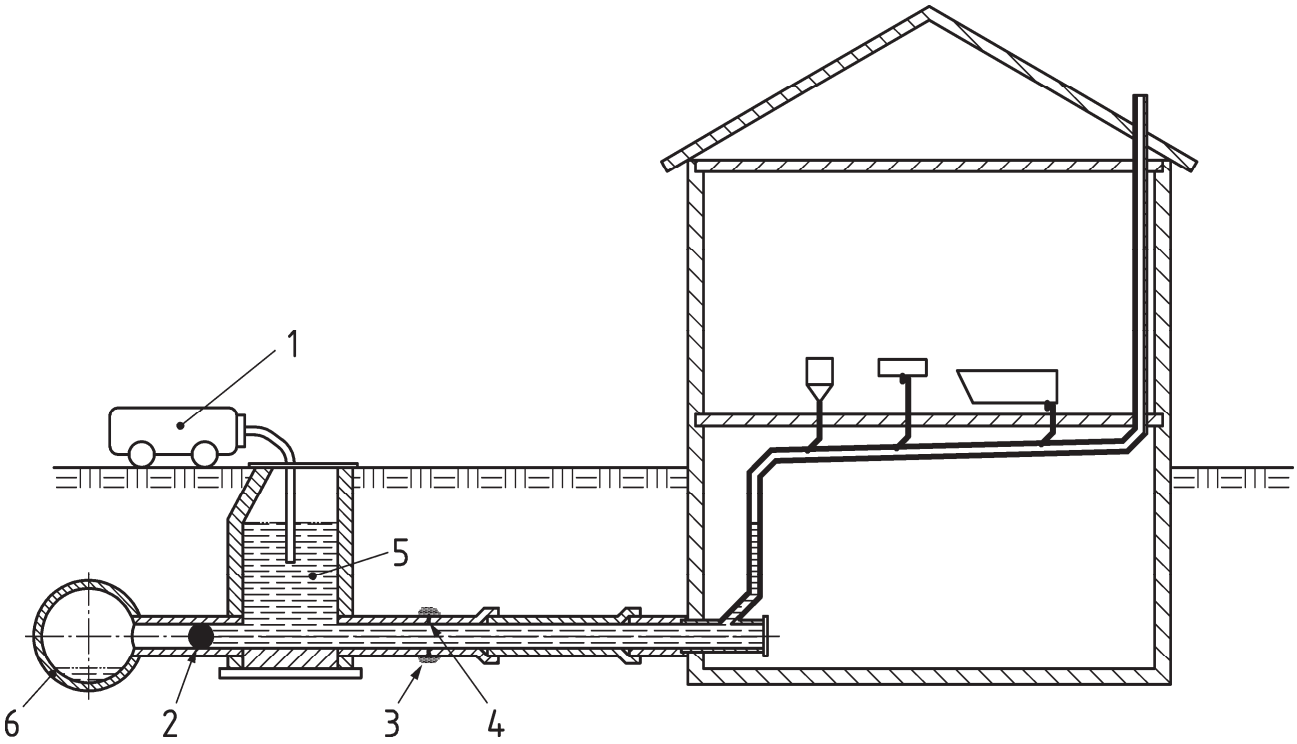

Key

1	solution tank	4	filled void
2	stopper	5	solution
3	solution penetrates through defects into surrounding ground	6	main sewer

Figure 17 — Repair by flood grouting

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Table 13 — Features of repair by flood grouting

Feature:	non man entry
Relevant standards:	none
Materials:	two component acrylic or silicate gels
Application:	– non pressure local drainage networks in porous bedding; – sealing of leaks through small holes and gaps by permeating porous surrounding soil with gel; not for filling cracks or voids in pipes, manholes or soil
Geometric capabilities	– any shape of pipe; – typical minimum size of main pipe: 100 mm; – typical maximum size of main pipe: 500 mm
Performance	– repairs using gel have limited resistance to surcharge pressure in gravity systems; – only for installations above ground water table; – repairs using gel are non stabilising; – does not adhere to host pipe; – no reduction in hydraulic capacity; – technique does not improve the abrasion resistance; – technique does not improve the chemical resistance
Installation characteristics	a) identification of local drainage network to be treated and isolation by plugging all ends; b) a four stage process required: 1) filling cleaned network with component A; 2) pumping out component A and cleaning pipe network; 3) filling network with component B; 4) pumping out component B and cleaning pipe network; This process repeated until sealing achieved; c) surface working space minimal; d) flow diversion generally required for installation; e) circular and non circular cross section; f) repair does not resist internal pressure; g) resistance to external water pressure depends on penetration of the repair material into the surrounding soil; h) access through manholes is possible; i) flow diversion generally required for installation; j) no reduction in cross section; k) no step in invert at ends of repair

7 Classification of performance characteristics for renovation and repair

7.1 General

EN 752 sets out the objectives of drain and sewer systems outside buildings.

Before a rehabilitation technique is chosen, the required function of the new pipe/liner in service shall be determined in accordance with EN 752.

The required functions generally include one or more of the following:

a) separation of the inner surface of the existing pipeline from the transported fluid to prevent mutual adverse reactions (e.g. corrosion of the existing pipeline by aggressive water);

b) sealing of the existing pipeline against infiltration of ground water or exfiltration of the transported fluid through leaking joints, cracks or holes;

c) stabilising or strengthening of the existing pipeline structure (e.g. where corrosion has resulted in loss of structural integrity, or to allow for increases in operating pressure);

d) providing sufficient hydraulic capacity (e.g. by creating a smooth flow path).

7.2 Structural integrity

7.2.1 External loads capacity

Four performance levels are defined in Table 14.

Table 14 — Performance levels on Structural integrity based on External Loads capacity (SEL)

Performance level	Characteristics
SEL4	resists ground water and/or internal negative pressure (short term)
SEL3	SEL4 + resists ground water and/or internal negative pressure (long term)
SEL2	SEL3 + absorbs or resists ground and traffic loading
SEL1	SEL2 + absorbs or resists ground movements

7.2.2 Internal loads capacity

Tables 15 and 16 define two and four performance levels respectively.

Table 15 — Performance levels regarding internal pressure capabilities

Performance level	Characteristics
G	for gravity pipeline applications
P	for pressurized pipeline applications

Table 16 — Performance levels on Structural integrity based on Internal Loads capacity (SIL)

Performance level	Characteristics
SIL4	provides internal barrier layer
SIL3	SIL4 + long-term hole and gap spanning at design pressure (DP)
SIL2	SIL3 where liner has independent ring stiffness (i.e. not dependent on adhesion to the host pipe)
SIL1	SIL4 + long-term independent pressure resistance to design pressure (DP) + can survive internally or externally induced (burst, bending or shear) failure of host pipe

7.3 Impacts on site

The site impact of different technique families is distinguished by overall working area, including:

a) surface area for equipment and material storage;

b) extent of excavation, if any, required for access.

NOTE For other environmental impacts such as noise, fumes, traffic, see EN 752.

Four site impact levels relating to excavation works are defined in Table 17.

Table 17 — Impact levels based on Excavation Works (EW)

Performance level	Characteristics
EW4	excavation necessary more than 10 m length
EW3	excavation necessary up to 10 m length
EW2	partial excavation of manhole necessary
EW1	no excavation necessary

7.4 Technique requirement for man entry

Two classes of man entry requirement are defined in Table 18.

Table 18 — Accessibility to the pipe

Performance level	Characteristics
NM	non man entry
ME	man entry

7.5 Technique requirement for shape

Two classes of shape requirement are defined in Table 19.

Table 19 — Accessibility to the pipe

Performance level	Characteristics
CS	circular shape only
NC	non circular and circular shapes possible

7.6 Hydraulic performance

Because of the influence of existing pipe characteristics on hydraulic performance of the renovated pipeline, hydraulic performance levels cannot be classified with reference to the lining system alone.

Hydraulic capacity includes both volumetric capacity and flow capacity.

All liners reduce volumetric capacity to some degree depending on technique (affecting annular gap, liner wall thickness) and pipe size. Many liners however do not reduce flow capacity because the reduction in diameter is more than offset by improvements in continuity of invert and hydraulic smoothness. The effect on flow capacity also depends on the gradient of the existing sewer.

8 Performance levels for renovation and repair

The viability of renovation or repair technique will depend on:

a) general information about the existing pipeline;

b) pipeline condition affecting performance level required as specified in Clause 7;

c) site conditions affecting installation.

Typical performance levels for each renovation or repair technique family are summarized in Table 20.

NOTE Not all the individual techniques in each family can necessarily achieve the maximum performance levels indicated.

Table 20 — Typical highest performance levels of renovation and repair techniques

Renovation and repair technique families	external loads capacity (highest possible) SEL	internal loads capacity (highest possible) SIL	Site impact (diameter dependent) EW	Man entry	Shape
Lining with continuous pipes	SEL1	SIL1	EW3	NM	NC
Lining with "close-fit" pipes	SEL1	SIL1	EW1 to EW3	NM	CS
Lining with "cured-in-place" pipes	SEL1	SIL2	EW1 to EW2	NM	NC
Lining with discrete pipes	SEL1	SIL1	EW1or EW2	NM	NC
Lining with "spirally-wound" pipes	SEL1	SIL 4	EW1	NM	CS
Lining with a rigidly anchored inner plastics layer	SEL2	SIL 4	EW1 or EW2	NM	NC
Lining with pipe segments	SEL2	SIL 4	EW2	ME	NC
Lining with sprayed, trowelled or cast in place material	SEL2	SIL 4	EW1	NM or ME	NC
Repair techniques	technique dependent	technique dependent	EW1	ME	NC

Annex A
(informative)

Place of this European Standard in the context of the overall design of renovation and repair of drains and sewers

Table A.1 illustrates the steps leading to and including the determination of viable solutions for any given set of renovation or repair objectives.

The initial steps, investigation and condition evaluation in accordance with EN 13508-1, provide the data from which the objectives for renovation or repair can be assessed.

Clause 7 provides a system of classification of structural and hydraulic performance levels, and the site impact characteristics of different technique families, based on which viable renovation and/or repair options can be determined from the list outlined in Clause 8. This identification of viable options in turn provides the basis for the final steps of selection, installation and operation.

Table A.1 — Position of this document in the context of other EN in the rehabilitation of drains and sewers

<table>
<tr><th>Step</th><th colspan="4">Applicable ENs [a]</th></tr>
<tr><td>Investigation</td><td colspan="3" rowspan="2">EN 13508-1</td><td rowspan="6">EN 752</td></tr>
<tr><td>Condition evaluation</td></tr>
<tr><td>Further design considerations</td><td rowspan="3">This EN</td><td rowspan="2">EN 13380</td><td rowspan="5">b</td></tr>
<tr><td>Assessment of performance objectives</td></tr>
<tr><td>Determination of viable options</td><td>Product standards where available (e.g. EN 13566 (all parts))</td></tr>
<tr><td>Selection of option</td><td>–</td><td>–</td></tr>
<tr><td>Structural and other detailed design</td><td colspan="3">c</td></tr>
<tr><td>Installation</td><td rowspan="2">–</td><td>Product standards where available
(e.g. EN 13566 (all parts))</td><td rowspan="2">b</td><td rowspan="2">EN 752</td></tr>
<tr><td>Operation and maintenance</td><td>–</td></tr>
</table>

a Not necessarily exhaustive.

b Standard regarding management and control of operational activities in drains and sewer Rehabilitation: in preparation.

c Specified by national/local guidelines only.

Bibliography

[1] EN 805, *Water supply — Requirements for systems and components outside buildings*

[2] EN 13380, *General requirements for components used for renovation and repair of drain and sewer systems outside buildings*

[3] EN 13508-1, *Condition of drain and sewer systems outside buildings — Part 1: General requirements*

[4] EN 13566-1, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 1: General*

[5] EN 13566-2, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 2: Lining with continuous pipes*

[6] EN 13566-3, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 3: Lining with close-fit pipes*

[7] EN 13566-4, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes*

[8] EN 13566-7, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 7: Lining with spirally-wound pipes*

[9] CEN/TR 15128, *Survey of European Standards for rehabilitation of drain and sewer systems*

[10] EN ISO 11295:2010, *Classification and information on design of plastics piping systems used for renovation (ISO 11295:2010)*

[11] ISO 11296-1:2009, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 1: General*

[12] ISO 11296-3:2009, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 3: Lining with close-fit pipes*

[13] ISO 11296-4:2009, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes*

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