Deutsches Institut für Bautechnik

DIBT

General Technical Approval

Approval Body for Construction Products & Types
Construction Engineering Inspection Body
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Z-42.3-375

Valid

from: **30 April 2016**

until: **30 April 2021**

Applicant:

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Object of Approval:

"epros®DrainLiner method" with the resin system "epros®EPROPOX HC60" for the rehabilitation of buried damaged sewer lines with nominal diameters from DN 100 to DN 400

The above object of approval is hereby granted general technical approval.
The present General Technical Approval covers 32 pages and 33 appendices.
This General Technical Approval replaces the General Technical Approval No. Z-42.3-375 of 17 April 2014 as extended by the Decision of 28 April 2015.

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I GENERAL PROVISIONS

1 The General Technical Approval is proof of the usability or applicability of the object of approval for the purpose of the German Lands' building regulations.

2 Where the General Technical Approval calls for specific expertise and experience of the persons commissioned to manufacture construction products and construction types according to the regional German state provisions as equivalent to § 17 (5) of the Reference Building Code (*Musterbauordnung*), it is important to note that such expertise and experience can also be proven by means of equivalent supporting documents from other member states of the European Union. This may also apply to equivalent supporting documents submitted under the Agreement on the European Economic Area (EEA) or other bilateral agreements.

3 The General Technical Approval shall be no substitute for the permits, consents and certificates statutorily prescribed for the implementation of building projects.

4 The General Technical Approval is granted without prejudice to any third-party rights including but not limited to private proprietary rights.

5 Manufacturers and distributors of the object hereof shall, notwithstanding any additional regulations laid down in the "Special Provisions" chapter, provide the user of said object with copies of the General Technical Approval and shall instruct the user to the effect that the General Technical Approval must be kept at the point of use or application. Copies of the General Technical Approval shall be provided to the authorities interested whenever requested by them.

6 The General Technical Approval may not be reproduced unless in total. Any publication of part of this Approval shall require the consent of the German Institute for Construction Engineering. Texts and drawings in advertising materials shall not be contradictory to the General Technical Approval. Translations of the General Technical Approval must contain the information that the "translation of the German original version has not been verified by the German Institute for Construction Engineering".

7 The General Technical Approval is granted subject to revocation. The provisions of the General Technical Approval may be amended by subsequent modifications or additions, especially where required by new technical findings.

II SPECIAL PROVISIONS

1 Object of approval and scope of application

This General Technical Approval applies to the "epros®DrainLiner Method" (Appendix **1**) for the rehabilitation of damaged sewer lines with circular cross sections in the nominal diameters from DN 100 to DN 400 with the three types of liner tubes named "epros®DrainLiner", "epros®DrainFlexLiner" and "epros® DrainSteamLiner", and with circular cross sections in the nominal diameters from DN 100 to DN 250 with the "epros®DrainPlusLiner" tube as well as the related epros®epoxy resin system "epros®EPROPOX HC60 (A)" (resin) and "epros®EPROPOX HC60 (B)" (hardener).

This General Technical Approval also applies to the "epros®DrainLCR Method" using the "epros®DrainLCR hat profile" along with the resin systems determined in the General Technical Approvals No. Z-42.3-385, No. Z-42.3-466, and No. Z-42.3-468, as well as the resin system "epros®EPROPOX HC60".

This Approval applies to the rehabilitation of sewer lines intended for the discharge of sewage as laid down in the standard DIN 1986-3[1].

The cured-in-place pipe lining (CIPP) method can be used for the rehabilitation of sewer pipes made of concrete, reinforced concrete, vitrified clay, asbestos cement, the plastic materials GRP, PVC, PE, PP, and cast iron, if the cross section of the sewer to be repaired meets the method-related requirements and structural stability needs.

Damaged sewer pipes are rehabilitated by the introduction and subsequent curing of a resin-wetted polyester needle nonwoven (felt) tube. For this purpose, a polyester needle felt (PES) tube with a surrounding outside flexible polyvinylchloride (PVC) coating, or a polyurethane (PUR) coating, or a polypropylene (PP) coating is wetted with a two-component epoxy resin (EP resin) on the job site.

The polyester needle felt tube is available in seven different film coating variants (refer to Appendix 1 item 4):

Variant	a)	"epros®DrainLiner" DN 100 to DN 400 PVC coated	(PVC film as installation aid for the liner tube)
Variant	b)	"epros®DrainLiner" DN 100 to DN 400 PP coated	(PP film as installation aid for the liner tube)
Variant	c)	"epros®DrainFlexLiner" DN 100 to DN 400 PP coated	(PP film as installation aid for the liner tube)
Variant	d)	"epros®DrainPlusLiner" DN 100 to DN 250 PUR coated	(PUR film as installation aid for the liner tube)
Variant	e)	"epros®DrainPlusLiner" DN 100 to DN 250 silicone coated	(SK film as installation aid for the liner tube)
Variant	f)	"epros®DrainSteamLiner" DN 100 to DN 400 PP coated	(PP film as component part of the liner tube)

In the CIPP closed-end method, the polyester needle felt tube is inverted into the damaged host sewer pipe by means of compressed air in connection with an inversion drum and is then cured by means of hot water (VARIANT 1) or steam (VARIANTS 2 and 3). For liner installation according to the "water column" variant (VARIANT 4), the polyester needle felt tube is inverted into the host line using a head of water. The open-end lining method uses an additional

[1] DIN 1986-3 Drainage facilities for buildings and properties – Part 3: Rules for operation and maintenance; issue 2004-11

calibration hose, which is inverted in a separate or simultaneous operation. Due to the inversion of the polyester needle felt tube, the PVC, PUR, SK or PP coating is turned to the inside facing the sewage flow. Air or water pressure is used to press the tube in a tight fit against the inner wall of the host pipe. The resin-wetted polyester needle felt tube is cured by means of hot water circulation.

In groundwater-saturated zones (groundwater infiltration), it is required to install a protective polyethylene tube (PE preliner) before inverting the resin-wetted polyester needle felt tube.

Waterproof reconnections of laterals in lines with nominal diameters between DN 100 and DN 200 shall be performed according to the "epros®DrainLCR method" of the General Technical Approvals No. Z-42.3-385, Z-42.3-466 and Z-42.3-468, or with other rehabilitation techniques under valid general technical approvals. It is also possible to reconnect laterals by open construction.

Pipe-to-manhole connections shall be made with swelling tapes (auxiliary material). Where it is not possible to use swelling tapes, the waterproof connection between the liner and the manhole wall can instead be made in the following way after the liner is cured:

a) Liner-to-manhole connection by application of a reaction resin compound having a valid general technical approval;

b) Liner-to-manhole connection by application of grout systems having a valid general technical approval;

c) GRP laminates;

d) Pressure injection of polyurethane (PU) or epoxy (EP) resins having a valid general technical approval;

e) Installation of liner end sleeves having a valid general technical approval.

2. Provisions regarding the method components

The liner tubes mentioned in the foregoing Section 1 meet the requirements laid down in DIN EN ISO 11296-4[2], where appropriate, and have the specific properties and compositions mentioned below.

2.1.1 Materials of the method components in the "M" condition

2.1.1.1 Materials for the inversion tubes (Appendix 1)

The materials of the polyester needle felt tube (PES tube), its coating made of PVC, PUR, SK or PP films, and the materials of the epros® epoxy resin system named "epros®EPROPOX HC60", inclusive of fillers, hardeners or other additives used, are in compliance with the formulation data kept with the German Institute for Construction Engineering (DIBt).

- The properties of the polyester needle felt tube (PES tube) include:

  1. "epros®DrainLiner" DN 100 to DN 400 – PVC or PP coated:

Mass per unit area:	Table A in Appendix **2**
PVC layer thickness:	0.40 mm to 0.50 mm
PP layer thickness:	0.30 mm to 0.40 mm

[2] DIN EN ISO 11296-4 Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks -- Part 4: Lining with cured-in-place pipes (ISO 11296-4:2009, corrected version 2010-06-01); German version EN ISO 11296-4:2011; issue:2011-07

2. "epros®DrainFlexLiner" and "epros®DrainSteamLiner" DN 100 to DN 400 – PP coated:
   Mass per unit area: Table B in Appendix **3**
   PP layer thickness "epros®DrainFlexLiner": 0.30 mm to 0.40 mm
   PP layer thickness "epros®DrainSteamLiner": 0.40 mm to 0.60 mm

3. "epros®DrainPlusLiner" DN 100 to DN 250 – PUR or SK coated:
   Mass per unit area: Tables C and D in Appendix **4** and Tables E and F in Appendix **5**
   PUR layer thickness: 0.20 mm to 0.25 mm
   SK layer thickness 0.20 mm to 0.60 mm

- The properties of the "epros®EPROPOX H60" resin system include:

4. The epoxy resin component A of the two-component resin system "epros® EPROPOX HC60" has the following initial properties before application:
   Density at +23°C: 1.16 g/cm³ ± 0.05 g/m³
   Viscosity at +25°C: 10,500 mPa x s ± 1,500 mPa x s

5. The hardener component B of the two-component resin system "epros® EPROPOX HC60" has the following initial properties before application:
   Density at +23°C: 0.95 g/cm³ ± 0.10 g/m³
   Viscosity at +25°C: 250 mPa x s (–100 +50) mPa x s

6. The epoxy resin system "epros®EPROPOX HC60", in the cured condition and without the PES liner, has the following properties after DIN 16946-2[3], Table 1 Type 1040-0:
   Density at +23°C: 1.15 g/cm³ ± 0.02 g/cm³
   Flexural modulus: approx. 2,800 N/mm²
   Flexural stress σ_{fB}: approx. 110 N/mm²
   Tensile strength: approx. 70 N/mm²
   Elongation at tear: > 7%
   Heat deflection temperature according to DIN EN ISO 75-2[4] approx. 95 °C
   Reactivity (pot time) at +25°C: 60 min

[3] DIN 16946-2 Reaction Resin Moulded Materials; Moulded Casting Resin Materials, Types; Issue: 1989-03

[4] DIN EN ISO 75-2 Plastics – Determination of temperature of deflection under load – Part 2: Plastics and ebonite (ISO 75-2:2004); German version EN ISO 75-2:2004; Issue:2004-09

Table 1: Mixing viscosity "epros®EPROPOX HC60 (A+B)"

Test temperature	Viscosity [mPas] at		
	10min after mixing (start value)	60min after mixing (end of pot time)	70min after mixing (end of measurement)
10°C	**20600**	**29762**	**32982***
15°C	**9517**	**15525**	**17522***
20°C	**4839**	**9724**	**11356**
25°C	**2617**	**7315**	**9265**

* The measured values for the mixing viscosities at 10°C and 15°C were extrapolated after 60 minutes and 53 minutes, respectively. Due to the low test temperatures, the measurements at 10°C and 15°C were distorted by condensation effects briefly before the end of measurement

No resins other than epoxy resins (EP resins) of the type 1040-0 laid down in Table 1 of the standard DIN 16946[3] shall be used, and they must conform to the formulation data and IR spectrums kept with the German Institute for Construction Engineering. The IR spectrums shall also be kept with the independent inspection body.

2.1.1.2 Materials for the "epros®DrainLCR Method" using the "epros®DrainLCR hat profile"

The materials for the "epros®DrainLCR hat profile" under the General Technical Approvals No. Z-42.3-385, No.Z-42.3-466, No. Z-42.3-468 conform to the formulation data kept with the German Institute for Construction Engineering such as the properties and the composition of the fibreglass-reinforced polypropylene as well as the silicate and epoxy resin systems inclusive of the fillers, hardeners or other additives used.

The silicate resins (winter and summer resins) conform to the IR spectrums kept with the German Institute for Construction Engineering. The IR spectrums shall also be kept with the independent inspection body.

2.1.1.3 Material for the swelling tape (auxiliary material)

No materials other than extruded profiles made of a chloroprene (CR/SBR) rubber and water-absorbent resin shall be used for the swelling tape (auxiliary material) at the pipe/manhole interface (Appendix **20**). The swelling tapes must provide a volume increase of no less than 100% after immersion in water for 72 hours.

2.1.2 Liner tube in the "I" condition

2.1.2.1 Wall thickness

Due to the general system design, the lining operations use resin-wetted liner tubes providing a minimum wall thickness of 3 mm after installation and cure (see Tables 2 and 3).

Self-supporting sewer lines (structurally stable in themselves without being supported by surrounding soils), i.e. with no cracks in them (except for hairline cracks with widths less than 0.15 mm or, in case of reinforced concrete pipes, less than 0.3 mm), may be repaired with liners according to Tables 2 and 3 only in case the wall thickness will not fall below a minimum value of 3 mm and a nominal stiffness value of SN ≥ 500 N/mm² will be met. If the host pipe has one or several continuous longitudinal cracks, it will be necessary to carry out soil investigations, e.g. by dynamic penetration tests, and to furnish calculations as appropriate proof. In infiltration cases, the liner must be dimensioned to its deformation and deflection (buckling) behaviour.

If the host pipe-soil system is no longer stable in itself, such sewer lines may be relined with CIPP liners of the wall thicknesses specified in the Tables 2 and 3 only if a structural calculation according to DWA-A 143-2[5] is furnished as proof of the liner's ability to withstand the structural loads acting on it.

The calculations for the initial ring stiffness SR of the cured liner must take into account the wall thicknesses given in Tables 2 and 3.

Table 2: Minimum wall thicknesses of the cured liner and nominal stiffness SN [N/m²][1)]

Outer diameter	Wall thickness							
	3.0 mm	3.5 mm	4.5 mm	6.0 mm	7.5 mm	9.0 mm	10.5 mm	12.0 mm
100 mm	6,656.27	10,735.07	23,540.19	-	-	-	-	-
125 mm	3,345.54	5,378.46	11,718.15	-	-	-	-	-
150 mm	1,912.47	3,068.13	6,656.27	16,276.04	-	-	-	-
200 mm	794.60	1,271.45	2,743.97	6,656.27	-	-	-	-
225 mm	555.25	887.70	1,912.47	4,627.05	-	-	-	-
250 mm	403.14	644.07	1,385.69	3,345.54	-	-	-	-
300 mm	231.89	370.09	794.60	1,912.47	3,793.05	6,656.27	10,735.07	16,276.04
350 mm	145.40	231.89	497.14	1,193.88	2,362.57	4,136.63	6,656.27	10,068.76
375 mm	118.01	188.15	403.14	967.29	1,912.47	3,345.54	5,378.46	8,128.42
400 mm	-	154.76	331.42	794.60	1,569.81	2,743.97	4,407.86	6,656.27

1 SN and SR stiffness calculation with initial E-modulus E = 2,700 N/mm² acc. to DIN EN 1228

Table 3: Minimum wall thicknesses of the cured liner and initial specific ring stiffness values SR [N/mm²][1)]

Outer diameter	Wall thickness s							
	3.0 mm	3.5 mm	4.5 mm	6.0 mm	7.5 mm	9.0 mm	10.5 mm	12.0 mm
100 mm	0.053	0.088	0.188	-	-	-	-	-
125 mm	0.027	0.043	0.094	-	-	-	-	-
150 mm	0.015	0.025	0.053	0.130	-	-	-	-
200 mm	0.006	0.010	0.022	0.053	-	-	-	-
225 mm	0,004	0.007	0.015	0.037	-	-	-	-
250 mm	0,003	0,005	0.011	0.027	-	-	-	-
300 mm	0,002	0,003	0.006	0.015	0.030	0.053	0.086	0.130
350 mm	0,001	0,002	0.004	0.010	0.019	0.033	0.053	0.081
375 mm	0,001	0,002	0.003	0.008	0.015	0.027	0.043	0.065
400 mm	-	0,001	0.003	0.006	0.013	0.022	0.035	0.053

1 SN and SR stiffness calculation with initial E-modulus E = 2,700 N/mm² acc. to DIN EN 1228

The following relationships apply to nominal stiffness SN and initial specific ring stiffness SR:

For SN:

$$SN = \frac{E \cdot s^3}{12 \cdot d_m^3}$$

For SR:

$$SR = \frac{E \cdot s^3}{12 \cdot r_m^3}$$

5 DWA-A-143-2 German Association for Water, Wastewater & Waste (DWA) – Worksheet No. 143 – Rehabilitation of Drain and Sewer Systems Outside Buildings – Part 2: Structural Calculations for the Rehabilitation of Drain and Sewer Systems with Relining and Assembly Methods; issue: 2015-07

(SN = nominal stiffness following DIN 16 869-2[6]) (r_m=radius of centre of gravity)

For the groundwater load case, the CIPP liner shall be dimensioned in terms of buckling according to DWA-A 143–2[5] (refer also to Section 9).

If the host pipe lies in the groundwater-saturated zone, a preliner must be installed so that the CIPP liner will have a three-layered wall structure, which comprises the protective PE film, the polyester fibre layer and the PVC, PUR, SK or PP film (Appendix **1**). In zones where no groundwater is encountered, installers can do without the preliner. In such case, the CIPP liner will have a two-layered wall structure made up of the polyester fibre layer and the PVC, PUR, SK or PP film.

2.1.2.2 Physical characteristics of the cured polyester fibre/resin composite

The resin/hardener-wetted polyester fibre layer (without preliner and inner coating) must provide the following characteristic values after final cure:

- Density after DIN EN ISO 1183-2[7]: : 1.19 g/cm³ ± 5%
- Short-term modulus of elasticity after DIN EN 1228[8]: ≥ 2,700 N/mm²
- Flexural modulus after DIN EN ISO 11296-4[2] or DIN EN ISO 178[9]: ≥ 2,400 N/mm²
- Flexural stress σ_{fB} after DIN EN ISO 11296-4[2] or DIN EN ISO 178[9]: ≥ 60 N/mm²

2.1.2.3 Characteristics of the cured polyester fibre/resin composite from thermal analysis (DSC analysis)

The cured polyester fibre/resin composite shows the following limit values as determined by means of Differential Scanning Calorimetry (DSC):

Glass transition temperature T_{G1} (actual condition of the reaction resin system; first heating phase)

approx. +45 °C

Glass transition temperature T_{G2} (resin system in its fully cured condition; second heating phase)

approx. +110 °C

2.1.2 Environmental compatibility

The construction product meets the requirements of the DIBt principles “Assessment of the impact of construction products on soils and groundwater” (Issue: 2011). This statement applies only in case the Special Provisions of this General Technical Approval are observed.

The requirement to obtain approval from the competent water authorities, especially in protected water zones, shall not be affected thereby.

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6 DIN 16 869-2 Pipes of glass fibre reinforced polyester resin, wound, filled – Part 2: General quality requirements; testing; issue: 1995-12

7 DIN EN ISO 1183-2 Plastics -- Methods for determining the density of non-cellular plastics -- Part 2: Density gradient column method (ISO 1183 2:2004); German version EN ISO 1183-2:2004; issue:2004-10

8 DIN EN 1228 Plastics piping systems – Glass-reinforced thermosetting plastics (GRP) pipes – Determination of initial specific ring stiffness; German version EN 1228:1996; issue:1996-08

9 DIN 1EN ISO 178 Plastics – Determination of flexural properties (ISO 178:2010); German version EN ISO 178:2010, issue: 2011-04

2.2 Manufacture, packaging, transport, storage and identification

2.2.1 Manufacture

2.2.1.1 Industrial manufacture of liner tubes

The polyester needle felt tubes with the minimum wall thicknesses given in Section 2.1.3 shall be manufactured with an outer flexible PVC, PUR, SK or PP film in the sub-supplier's factory. The Applicant shall check to make sure the specified lengths and wall thicknesses are observed by the sub-supplier.

The Applicant shall request appropriate proof for verifying that the characteristics of the resin and the hardener, the fillers or other additives are in accordance with the formulation data.

The following properties shall be checked during the incoming goods inspection:

Properties of the resin:

– Density
– Viscosity

2.2.2 Packaging, transport, storage

The polyester needle felt tubes with a one-sided coating as delivered by the sub-supplier shall be stored in the premises of the Applicant in a way to ensure the tubes will not be damaged.

The components delivered by the sub-supplier for resin impregnation on the job site shall be stored until further use in suitable and separate hermetically closed containers in the premises of the Applicant. The storage temperature must range between approx. +15°C and approx. +35°C. The shelf life for the epoxy resin and the hardener is about 12 months after delivery and shall not be exceeded. The containers shall be protected from direct sunlight. They shall be designed such that the epoxy resin and the hardener as well as the silicate resin are kept in separate receptacles.

The usage amounts of each component as required for the rehabilitation jobs shall be withdrawn from the storage containers and then transported in safe, separate and hermetically closed receptacles to the given place of application. There, the transport containers must be protected from weather. The polyester needle felt tubes shall be transported in suitable containers ensuring they are not damaged.

The relevant rules and regulations of accident prevention as well as the instructions given in the Applicant's method statement shall be observed.

2.2.3 Identification

The polyester needle felt tubes and the transport containers of the resin components shall be identified with the compliance mark ("Ü") in accordance with the applicable compliance and conformity regulations of the German *Länder*, inclusive of the Approval number Z-42.3-375. Said identification is subject to the condition that the requirements set forth in Section 2.3 Proof of Compliance have been met.

In addition, the transport containers of the polyester needle felt tubes shall show the following information:

– Nominal diameter
– Length
– Batch number
– PVC, PUR, SK or PP film coatings
– Reference to PP film as component part of the liner

In addition, the transport containers for resins, hardeners and other additives shall be identified with the following minimum information:

– Component designation
– Temperature range
– Quantity contained (volume or weight)
– Where required: Hazard symbol according to the hazardous substance regulation

2.3 Proof of Compliance

2.3.1 General

The confirmation that the method components are in compliance with the provisions of this General Technical Approval must be provided for each manufacturing factory by means of a Compliance Certificate based on in-house production control and regular third-party inspection including initial testing of the method components subject to the following conditions.

For obtaining the Compliance Certificate and for third-party inspection including the related product tests, the manufacturer shall commission a generally accepted certification body as well as an accredited inspection body.

To confirm the issuance of a Compliance Certificate, the manufacturer shall identify the construction products with the compliance mark ("Ü") while indicating the purpose of use.

The certification body shall provide one copy of its Compliance Certificate to the German Institute for Construction Engineering for information.

In addition to that, the German Institute for Construction Engineering shall be given for information a copy of the initial test report.

2.3.2 In-house production control

Every manufacturing plant shall implement and carry out in-house production control. In-house production control shall mean the continuous inspection or monitoring of the production by the manufacturer to ensure that the construction products made by the manufacturer comply with the provisions of this General Technical Approval.

In-house production control should include the following minimum requirements:

– Description and inspection of the base material

  For each delivery of the incoming components of PVC, PUR, SK or PP films, polyester fibre, resin, hardener or other additives, the operator of the manufacturing plant shall check and make sure the properties required under Section 2.1.1 are met.

  For this purpose, the operator of the manufacturing plant shall cause each of the sub-suppliers to submit certificates of compliance 2.1 after DIN EN 10204[10]. In addition, the incoming goods inspection shall include a random check verifying the properties specified in Section 2.1.1.1 hereof in accordance with the methods kept with the German Institute for Construction Engineering.

[10] DIN EN 10204 Metallic products – Types of inspection documents; German version EN 10204:2004; issue: 2005.01

– Checks and inspections to be performed during manufacture

  It is to be checked that the requirements laid down in Section 2.2.1 are fulfilled.

– Inspection of containers:

  Check every resin batch for meeting the identification requirements set forth in Section 2.2.3.

The results of in-house production controls shall be recorded. The records shall contain at least the following information:

– Designation of the construction product or base product and its components
– Type of control or inspection
– Date when the construction product or base material was manufactured and inspected
– Result of the control checks and inspections and, where appropriate, comparison with the requirements
– Signature of the person responsible for in-house production control

The records shall be kept for at least five years and submitted to the external inspection body commissioned for third-party inspection. If so requested, they shall be submitted to the German Institute for Construction Engineering and to the competent supreme building inspection authority.

If the inspection result is not satisfactory, the manufacturer shall immediately take the actions required for correcting the defect. Non-conforming construction products shall be handled in a way to ensure no confusion with conforming products is possible. Once the defect has been corrected, the failed test or inspection shall be repeated immediately – where technically feasible and required for proving the success of the corrective action.

2.3.3 Third-party inspection

In every manufacturing plant, the in-house production control system shall be inspected and verified by an external body at regular intervals, but at least twice a year.

The scope of third-party inspection includes an original inspection (initial testing) of the method components. In-house production control shall be performed on the basis of random checks within the scope of third-party inspection. The control checks shall verify compliance with the requirements under Sections 2.1.1 and 2.2.3.

Furthermore, there shall be random checks for compliance with the manufacturing requirements laid down in Section 2.2.1. These include the verification of curing behaviour, density, storage stability, and mass per unit area, as well as IR spectroscopies.

In each case, the accredited inspection body is responsible for sampling and testing. During third-party inspection, the certificates of compliance 2.1 after DIN EN 10204[10] shall be verified as well.

The results of the certification and third-party inspection processes shall be kept for no less than five years. If so requested, they shall be submitted by the certification body or the inspection body to the German Institute for Construction Engineering and to the competent supreme building inspection authority.

3 Provisions for the design

The necessary pipeline data shall be verified, e.g. routing, depth, positions of laterals, manhole depths, groundwater, pipe joints, hydraulic conditions, inspection holes, cleaning intervals. Existing video takes must be analyzed for application-specific evaluation. The accuracy of the data must be verified on the job site. The condition of the existing sewer line of the property drainage system must be assessed for applicability of the pipelining method.

The hydraulic capacity of the sewer lines shall not be affected by the installation of a liner. If necessary, appropriate proof shall be furnished.

4 Provisions for the performance of the work

4.1 General

The cured-in-place pipelining "epros®DrainLiner Method" can be applied in the following constructions:

a) From the start to the end point

b) From the start to the end point through an intermediate manhole

c) From the start point in the main line down into a pipe run for a defined length with no further manhole or access pit being needed

d) Lateral connections, from the start point down to the main/lateral interface in the main line or from the main line start point to the lateral connection point.

The start (entry) or end (exit) points can be a manhole, an inspection or cleaning hole, or an open pipe socket. The basic condition is that the size of the opening is sufficient for accommodating the inversion fitting of the inversion plant.

Also, it is possible to cross several manholes along a run between a start point and an end point, including manholes with directional changes of the invert. The "epros®DrainLiner", the "epros®DrainFlexLiner" and the "epros®DrainSteamLiner", as well as the "epros®DrainPlusLiner" are able to reline manhole invert bends up to 45 degrees. Line bends up to 90 degrees can be relined with the "epros®DrainPlusLiner".

Wrinkles, if any, shall never exceed the values specified in DIN EN ISO 11296-4[2].

The waterproof relining of laterals (Appendices **15** to **18**) using the "epros®DrainLCR hat profile" in lines with nominal diameters between DN 100 and DN 200 shall be performed from inside the renovated line with the lining device ("epros®DrainLCR packer") and the resin systems of the General Technical Approvals No. Z-42.3-385, No. Z-42.3-466, No. Z-42.3-468 and/or with the resin system "epros®EPROPOX HC60", or with other relining methods having valid general technical approvals, or by open construction.

The Applicant shall prepare and provide to the installer a manual describing each of the steps to be carried out according to the type of performance of the lining method.

The Applicant shall also ensure installers are sufficiently familiarised with the method. Sufficient technical knowledge can be documented for the installer company by means of an appropriate quality mark of the German Association for Sewer Construction Quality Protection *Güteschutz Kanalbau e.V.*[11].

[11] Güteschutz Kanalbau e.V.; Linzer Str. 21, Bad Honnef, phone: (02224) 9384-0; fax: (02224) 9384-84

4.2 Equipment and installations

4.2.1 Minimum needs in equipment, components and installations required for implementing the lining method:

- Equipment for sewer cleaning operations
- Equipment for service flow management
- Equipment for sewer inspection (DWA-M 149-2[12])
- Installations for lining operations:
  - Polyester needle felt tubes in the appropriate nominal diameters (Appendix **1**) ("epros®DrainLiner", "epros®DrainFlexLiner", "epros®DrainSteamLiner" (DN 100 to DN 400), and/or "epros®DrainPlusLiner" (DN 100 to DN 250))
  - Heat and pressure-resistant calibration hoses according to the nominal diameters
  - Protective polyethylene films (PE preliners) according to the nominal diameter
  - Containers with resin and hardener "epros®EPROPOX HC60 (A)" and "epros®EPROPOX HC60 (B)"
  - Equipment for dosing and mixing the resin system (Appendix **19**)
  - Weatherproof impregnation point (table with belt conveyor or roller table and pinch roller system) with exhaust system where required (Appendix **19**)
  - Vacuum system (Appendix **19**)
  - Heat and pressure-resistant pressure hoses for connection to the inversion drum according to the given nominal diameter
  - Inflatable "epros®PipePlugs", or stop discs, for the given nominal diameter
  - Inversion bends in the appropriate size(s)
  - Supporting (sampling) pipes or tubes for obtaining samples on the job site (for the given nominal diameter)
  - Power generating set
  - Water supply
  - Power supply
  - Containers for residual waste
  - Temperature sensors
  - Temperature monitoring and recording equipment
  - Small equipment such as pneumatic cutting tools
  - Pneumatic drill
  - Hand tools, ropes
  - Social and sanitary rooms, where required

4.2.2 Additional components, equipment and installations required for the "hot water cure method":

- "epros®HWB" & "epros®HotBox" hot water units and accessories for hot water cure
- Control devices for flow and return water temperatures
- Inversion drum (VARIANT 1; Appendix **6**) with pressure monitor and hot water connection

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12 DWA-M 149-2 German Association for Water, Wastewater & Waste (DWA) – Information Sheet 149: Inspection and Assessment of the Condition of Drain and Sewer Systems Outside Buildings. Part 2: Coding system for optical inspection: 2011-06

- Inversion pipe, rig, cold water hose, suction line, hydrant connection, and accessories for the "water column" (VARIANT 4; Appendix **9**)
- Inversion cone or ring, or optionally stop rods

4.2.3 Additional components, equipment and installations required for the "steam cure method":

- "epros®SteamGen" steam generator with "epros®SteamTelemetry" (semi-automatic control) and/or "epros®SteamMixingLance" (hand control) and accessories for steam cure
- Inversion drum (VARIANTS 2 and 3; Appendices **7** and **8**) with pressure monitoring device and steam connection
- Steam temperature monitoring devices
- Pressure gauge
- Steam outlet
- Compressor, air hoses, air pressure regulator
- If required: blind plugs in the range between DN 100 and DN 400 (steam inlet plugs)

Any electrical equipment to be introduced into the pipe such as CCTV cameras (or so-called crawlers) must be in compliance with the VDE regulations.

4.2.4 Minimum needs in components, equipment and installations required for the lining of lateral connections with the "epros®DrainLCR Method" – in addition to the items mentioned in Section 4.2.1:

– "epros®DrainLCR hat profile" in the given nominal diameters
– Lining equipment ("epros®DrainLCR packer") and accessories (Appendix **15**).
– Containers with resin and hardener of the resin systems "epros®EPROPOX FC30" according to the General Technical Approval No. Z-42.3-466 and/or "epros®ResinType W01" and/or "epros®ResinType W1" and/or "epros®ResinType S" according to the General Technical Approval No. Z-42.3-385 and/or "epros®EPROPOX HC120" according to the General Technical Approval No. Z-42.3-468 and/or "epros®EPROPOX HC60"
– Locking air push rods (Variant a))
– Carriage (Variant b))
– Camera, control unit with monitor screen
– Lifting gear

4.3 Performance of lining work

4.3.1 Preparatory operations (Appendices 27 to 29)

The first step before starting the pipelining job is to ensure the host sewer is out of service; if necessary, the service flow shall be stopped by inflatable pipe plugs and be bypassed. The sewer to be relined shall be cleaned such that any existing defects can be clearly seen on the monitor. Obstacles shall be removed as necessary (e.g. root intrusions, protruding laterals etc.). Appropriate tools must be used for the removal of such obstacles to ensure the existing sewer suffers no additional damage.

The rules and regulations of accident prevention applicable to the lining method shall be observed.

All CIPP method equipment intended to enter the defective sewer section may not be used unless or until it has been ensured by appropriate inspection that there are no inflammable gases inside the sewer section to be repaired.

More specifically, the relevant sections of the following codes and regulations shall be complied with:

– GUV-R 126[13] (previously GUV 17.6)
– DWA-M 149-2[13]
– DWA-A 199-1 and DWA-A 199-2[14]

The job data stated in Section 3 shall be verified on the job site to make sure they are correct. The pipe run to be relined shall be cleaned with usual high-pressure cleaning equipment (jetters) to the extent necessary to ensure perfect visualisation of the pipe defects on the monitor during the optical inspection according to the Information Sheet DWA-M 149-2[12].

Specifically, where steam generators and steam cure equipment are used, the Machinery Safety Act and the Steam Boiler Regulation shall be observed.

When persons are sent down into manholes of sewer lines to be renovated as well as in all steps of the pipelining method, the relevant rules and regulations of accident prevention shall be complied with.

The steps required for the operation of the method shall be recorded for each impregnation and each lining job using the report forms shown in the Appendices **29** to **32**.

4.3.2 Inspection of incoming method components on the job site

The transport containers of the method components shall be checked for proper identification as specified in Section 2.2.3. The circumference of the polyester fibre tube as referred to the host pipe size shall be verified before the tube is wetted with resin. Also, it must be checked that the pre-impregnation storage temperature is maintained between +15°C and +35°C.

4.3.3 Placement of supporting pipes and tubes

Prior to the introduction of the PE preliner, it may be necessary to position supporting (sampling) pipes or tubes as an extension of the sewer line to be renovated, or in the region of intermediate manholes, to allow final samples to be taken there at the end of the pipelining job and to protect the liner from excessive elongation.

4.3.4 Installation of the PE preliner

The preliner shall be introduced into the host sewer line in a way to avoid damages. It is installed by inversion into the host pipe with the help of the inversion drum" (VARIANT 1, VARIANT 2 and VARIANT 3) by means of compressed air, or by means of a water head (VARIANT 4). The preliner may also be installed by pulling. The swelling tapes to be installed for creating a watertight seal shall be positioned in the region of the pipe-to-manhole interfaces during the introduction of the preliner (Appendix **20**).

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[13] GUV-R 126 — Safety rules: Work in confined spaces of wastewater facilities (previously GUV 17.6); issue: 2008-09

[14] ATV-DVWK-A 199-1 — German Association for Water, Wastewater & Waste (DWA) – Worksheet 199: Service and Operating Instructions of the Personnel of Waste Water Systems Part 1: Service Instructions for the Personnel of Wastewater Facilities; issue:2011-11

DWA-A 199-2 — German Association for Water, Wastewater & Waste (DWA) – Worksheet 199: Service and Operating Instructions of the Personnel of Waste Water Systems Part 2: Operating Instructions for the Personnel of Sewerage Systems and Stormwater Treatment Facilities; issue:2007-07

4.3.5 Impregnation of the polyester needle felt tube

a) Epoxy resin mixture for the "epros®DrainLiner", "epros®DrainFlexLiner", "epros®Drain SteamLiner" and "epros®DrainPlusLiner"

The resin amount required for wetting a given polyester needle felt tube shall be determined according to the liner material, diameter, wall thickness and length before the resin is mixed (Appendix **21**).

The mixing ratio between the epoxy resin and the hardener is 100:33 kg by weight, or 100:40 Litres by volume (see Appendix **21**). Once the container has been opened, the full amount of hardener must be added immediately to the resin. A double stirrer (electrically or air-operated) shall be used to uniformly mix the hardener component with the epoxy resin without bubbles in the resin container. An automatic dosing and mixing unit shall be used in case of larger usage amounts of approx. 180 Litres or more.

Resin and hardener usage amounts as well as the temperature conditions shall be recorded in the report according to Section 4.3.1.

A sample shall be taken from every resin batch to verify and report its reactivity.

b) Wetting with resin

The polyester needle fest tube shall be unrolled and placed on the conveyor table, or suspended from appropriate installations, in the weatherproof or air-conditioned room, or in the CIPP truck. Each component must be thoroughly mixed in itself before the components are mixed together. The mixing temperature shall never fall below ≥ +15°C. For better wetting, it is necessary to remove most of the air contained in the polyester needle felt tube. An appropriate negative pressure of about 0.5 bar in the polyester needle felt tube can be achieved by means of the following methods:

1. For shorter lengths, a vacuum incision shall be cut in the top coating at the end of the liner tube. Never cut the seam area. Three incisions of about 15 mm shall be made. They shall be in the coating only and will accommodate the suction cup of the vacuum unit.
2. For greater lengths or liner diameters, vacuum incisions shall be made at intervals of 7 m to 10 m in the top coating, but not in the seam area. Three incisions of some 15 mm shall be cut in the coating only. The cuts not used for the moment shall be covered with an adhesive tape. They will be used later and then closed.

Then the liner tube shall be folded into a "Z" shape. A weight shall be placed onto the "Z"-fold to hold it down. This helps a negative pressure build up between the folded liner and the suction cups. Another Z-fold shall be made downstream of every suction cup with a weight being placed on it. The open end of the liner shall be placed on the impregnation table and the resin mixture shall be poured into it. To achieve uniform distribution of the resin inside the polyester needle felt tube, the liner shall then be passed through a pinch roller system. For this purpose, the liner tube shall be placed under the pressing rollers. The nip shall be set to twice the wall thickness of the liner tube plus 2 mm. The relevant operating and maintenance instructions shall be made available and shall be observed for this operation.

The feed line speed shall be selected so as to achieve uniform distribution of the resin in the matrix of the polyester needle felt tube. The line speed of the impregnation process depends on the suction or penetration behaviour of the resin mixture.

For less friction during the following inversion step and for avoiding unnecessary temperature increases, the impregnated liner tube coming from the pinch rollers shall

immediately be folded into a container with a biodegradable lubricant in a way to ensure the folds will not damage the PVC, PUR, SK or PP film.

The cure time and the temperature curve shall be recorded in the report according to Section 4.3.1 both for closed-end inversion and for open-end inversion.

4.3.6 Inversion of the resin-wetted polyester needle felt tube

4.3.6.1. VARIANT 1: Pressure inversion by means of inversion drum and hot water cure (Appendix **6**)

Once the impregnation process is complete, the end of the liner tube together with the control tape shall be tied (to form the "liner head") and wound into the inversion drum. For inversion, the still open end of the liner tube shall be passed through the inversion tube to be connected to the inversion drum. This shall be done by means of a pull rope. The tube end shall be clamped to the pre-mounted "epros®InversionFitting" or "epros®InversionBend".

4.3.6.1.1 Inversion according to the closed-end method (Appendix **10**)

Step 1: Inversion by means of inversion drum

The "epros®InversionFitting" or "epros®InversionBend" with the liner end shall be introduced into the start manhole or inspection hole and positioned at the beginning of the host pipe, or at the PE preliner if any. Then the inversion pressure indicated in the Appendices **22** to **26** shall be applied to the inversion drum, depending on the given liner diameter and wall thickness. This pressure causes the liner tube to be inverted. The inversion process continues until the end manhole or exit inspection hole or target point of the defective sewer line is reached. As a result of this process, the resin-wetted interior side of the liner tube enters into contact either with the interior side of the PE preliner or directly with the inner surface of the host sewer pipe. So the PVC, PUR, SK or PP film is turned to the side of the service flow.

Step 2: Hot water cure

While the liner tube is filled with water, the compressed air shall be removed slowly at the inversion drum to prevent excessive total pressure in the liner. The liner shall be completely filled with water via the hot water / boiler system connected to the inversion drum in order to maintain the close fit to the inner wall of the host pipe. The hot water produced in the boiler shall be conveyed by a pump in the heating circuit (Appendix **6**). The circulating water shall be heated up to approx. +70°C in the flow line. The flow and return temperatures in the heating circuit as well as the temperature between the liner and the inner surface of the host pipe (at the start, intermediate and end points) shall be measured and recorded at the invert level (lowest point) during the entire cure period. The curing times given in Table **5** shall be observed. At the end of the cure (heating period), the temperature of the water and thus of the liner shall be reduced to approx. +20°C by the addition of cold tap water. Once said temperature level is reached, the water shall be drained. The curing times for the "epros®DrainLiner", "epros®DrainFlexLiner", "epros®DrainSteamLiner" or "epros®DrainPlusLiner" (Table 5) depend on the specific epoxy resin system according to Section 2.1.1.1 and on the prevailing ambient temperatures. The cure time and the applied pressure shall be measured and recorded during the entire cure time.

4.3.6.1.2 Inversion according to the open-end method (Appendices **11** to **14**)

Step 1: Inversion by inversion drum

Where the lining job runs from an entry manhole or inspection hole towards an inaccessible main line (or collector), the liner length must be determined in advance to prevent the liner from protruding into the main line. The end of the liner tube must be closed with a Teflon tape or an elastic rubber band before the liner is wound up.

The liner tube such closed shall be wound into the inversion drum. The next operations are the same as those described in sub-section 4.3.6.1.1 at Step 1.

At the end of the air-supported inversion process, the Teflon tape or rubber band will get loose and release the pressure from inside the liner. At this point, the liner is not yet in contact with the inner surface of the host pipe or the PE preliner installed before.

The liner tube shall be detached from the "epros®InversionFitting" or "epros® InversionBend". A calibration hose with a connected heating hose and control tape shall be wound into the inversion drum. The opposite end of the calibration hose shall be attached to the "epros®InversionFitting" or "epros®InversionBend". Then the calibration hose shall be inverted at the same pressure level as that mentioned at 4.3.6.1.1 Step 1. The calibration hose forces the liner against the inner wall of the host pipe or PE preliner in a close and tight fit.

Step 2: Hot water cure

The same operations as those described at 4.3.6.1.1 Step 2 shall be performed.

After final cure and completion of the cooling-down phase, the water shall be drained and the calibration hose shall be removed.

4.3.6.1.3 Inversion with open end and "epros®LinerEndCap" (open-end method, Appendix **14**)

Step 1: Inversion by inversion drum

Where the lining job runs from an entry manhole or inspection hole towards an inaccessible main sewer, the liner length must be determined in advance to prevent the liner from protruding into the sewer. The end of the liner tube shall be closed with the "epros®LinerEndCap" before the liner is wound up.

The liner tube such closed shall then be wound into the inversion drum. The next operations are the same as those described in sub-section 4.3.6.1.1 at Step 1.

At the end of the air-supported inversion process, the "epros®LinerEndCap" will get loose and release the pressure from inside the liner. At this point, the liner is not yet in contact with the inner surface of the host pipe or the PE preliner installed before.

The liner tube shall be detached from the "epros®InversionFitting" or "epros® InversionBend". A calibration hose with a connected heating hose and control tape shall be wound into the inversion drum. The opposite end of the calibration hose shall be attached to the "epros®InversionFitting" or "epros®InversionBend". Then the calibration hose shall be inverted at the same pressure level as that mentioned at 4.3.6.1.1 Step 1. The calibration hose forces the liner against the inner wall of the host pipe or PE preliner in a close and tight fit.

Step 2: Hot water cure

The same operations as those described at 4.3.6.1.1 Step 2 shall be performed.

After final cure and completion of the cooling-down phase, the water shall be drained and the calibration hose shall be removed.

4.3.6.2. VARIANT 2 and VARIANT 3: Pressurised inversion by means of inversion drum and steam cure (Appendix **7** and Appendix **8**)

4.3.6.2.1 Inversion with closed end and heating hose (Appendix **7**) (closed-end method, Appendix **10**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.1 Step 1 shall be performed.

Instead of the tied-up end of the liner tube, a heating hose shall be attached to the end of the liner tube and shall be inverted together with the liner tube. The heating hose shall be connected with the service window of the inversion drum.

Step 2: Steam cure

The curing pressure shall be kept constant at the values specified in the Appendices **22** to **26** by means of compressed air via the "epros®Steam Telemetry" (semi-automatic control) or "epros®SteamMixingLance" (hand control). The steam generator shall be started and, after the appropriate heating-up period, shall be connected to the "epros®SteamTelemetry" or "epros®Steam MixingLance" unit. The temperature shall be increased continuously by adding the appropriate amount of steam via the "epros®SteamTelemetry" or "epros®SteamMixingLance". The steam/air mixture shall exit the system through the start manhole or start point. The flow shall be controlled with the help of a ball valve fitted to the inversion drum. The pressure and the temperature shall be kept constant. The maximum steam/air temperature of +100°C shall never be exceeded.

Both the temperature of the steam/air mixture and the temperature between the liner and the inner wall of the host sewer (at the start and end points as well as at the intermediate manhole or line inspection hole, if any) shall be measured and reported during the entire cure period. The curing temperatures shall be measured between the inverted liner tube and the inner pipe wall surface of the sewer.

The curing times according to Table 5 shall be observed.

After final cure (completion of the heating phase), the liner tube shall be cooled with air down to a liner temperature of +20°C.

he curing times for the "epros®DrainLiner", "epros®DrainFlexLiner", "epros®Drain SteamLiner" and "epros®DrainPlusLiner" (Table 5) are variable depending on the epoxy resin system selected among those mentioned at Section 2.1.1.1 and on the prevailing ambient temperatures. The curing time and the applied pressure shall be measured and reported during the entire cure period.

4.3.6.2.2 Inversion with closed end and steam outlet valve (Appendix **8**) (closed-end method, Appendix **10**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.1 Step 1 shall be performed.

Instead of the tied-up end of the liner tube, the "epros®SteamOutlet valve" shall be incorporated and connected with the control tape of the inversion drum.

Step 2: Steam cure

The curing pressure shall be kept constant at the values specified in the Appendices **22** to **26** by means of compressed air via the "epros®SteamTelemetry" (semi-automatic control) or "epros®SteamMixingLance" (hand control). The steam generator shall be started and, after the appropriate heating-up period, shall be connected to the "epros®SteamTelemetry" or "epros®SteamMixingLance" unit. The temperature shall be increased continuously by adding the appropriate amount of steam via the "epros®SteamTelemetry" or "epros®SteamMixingLance". The steam/air mixture shall exit through the "epros® SteamOutlet valve" at the end of the liner tube. The maximum steam/air temperature of +100°C shall never be exceeded.

Both the temperature of the steam/air mixture and the temperature between the liner and the inner wall of the host sewer (at the start and end points as well as at the intermediate manhole or line inspection hole, if any) shall be measured and reported at the invert (lowest point) during the entire cure period. The curing temperatures shall be measured between the inverted liner tube and the inner pipe wall surface of the sewer.

The curing times according to Table 5 shall be observed.

After final cure (completion of the heating phase), the liner tube shall be cooled with air down to a liner temperature of +20°C.

The curing times for the "epros®DrainLiner", "epros®DrainSteamLiner" and "epros®DrainPlusLiner" (Table 5) are variable depending on the epoxy resin system selected among those mentioned at Section 2.1.1.1 and on the prevailing ambient temperatures. The curing time and the applied pressure shall be measured and reported during the entire cure period.

4.3.6.2.3 Inversion with open end and heating hose (Appendix **7** open-end method, Append. **11** to **14**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.2 Step 1 shall be performed.

The heating hose, instead of the liner tube, shall be connected to the calibration hose.

Step 2: Steam cure

The same operations as those described at Section 4.3.6.2.1 Step 2 shall be performed.

4.3.6.2.4 Inversion with open end and stem outlet valve (Appendix **8**) (open-end method, Appendices **11** to **14**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.2 Step 1 shall be performed.

Instead of the tied-up end of the liner tube, the "epros®SteamOutlet valve" shall be incorporated and connected with the control tape of the inversion drum.

Step 2: Steam cure

The same operations as those described at Section 4.3.6.2.2 Step 2 shall be performed.

4.3.6.2.5 Inversion with open end and "epros®LinerEndCap" and heating hose (open-end method, Appendix **14**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.3 Step 1 shall be performed.

The heating hose, instead of the liner tube, shall be connected to the "epros®LinerEndCap".

Step 2: Steam cure

The same operations as those described at Section 4.3.6.2.1 Step 2 shall be performed.

4.3.6.2.6 Inversion with open end and "epros®LinerEndCap" and steam outlet valve (open-end method, Appendix **14**)

Step 1: Inversion by inversion drum

The same operations as those described at Section 4.3.6.1.3 Step 1 shall be performed.

Instead of the tied-up end of the "epros®LinerEndCap", the "epros®SteamOutlet valve" shall be incorporated and connected with the control tape of the inversion drum.

Step 2: Steam cure

The same operations as those described at Section 4.3.6.2.2 Step 2 shall be performed.

4.3.6.3. VARIANT 4: Water inversion with "water column" by means of an inversion rig and hot water cure (Appendix **9**)

Step 1: Inversion by water gravity

For the installation of a liner according to the "water column" method variant, the polyester needle felt tube shall be inverted into the pipe by means of a water head created by a tower rig to be put up at the start point or entry manhole. The height of said rig shall be chosen according to the required hydrostatic pressure (water head) and the manhole depth. An "epros®InversionPipe" dimensioned to the diameter of the host pipe shall be positioned in the entry manhole or start point. The liner tube shall be introduced through the "epros®InversionPipe", then fixed and turned back through the holding ring. Then water shall be filled in. The head of water will cause the liner tube to invert into the sewer and provide the pressure necessary to press and hold the liner tube in a tight fit against the surface of the host pipe.

The appropriate inversion pressures are indicated in the Appendices **22** to **26**.

Step 2: Hot water cure

The same operations as those described at Section 4.3.6.1.1 Step 2 shall be performed.

4.3.6.4. Curing times

The curing times for the "epros®DrainLiner", "epros®DrainFlexLiner", "epros®Drain SteamLiner" and "epros®DrainPlusLiner" (Table 5) are variable depending on the epoxy resin system selected among those mentioned at Section 2.1.1.1 and on the prevailing ambient or process temperatures. The curing time and the applied pressure shall be recorded.

Table **5**: Curing times of the epoxy resin system "epros®EPROPOX HC60 (**A+B**)

Curing times in minutes	Curing temperatures
approx. 900	at +10°C
approx. 60	at +60°C for hot water circulation
approx. 30	at +80°C for hot water circulation
approx. 30	at +80°C for steam

The curing times (heating phase without cooling-down phase) start when the temperatures mentioned in Table 5 are reached, as measured between the inverted liner tube and the host pipe surface of the sewer to be relined (at the start, intermediate and end points) at the bottom of the invert (at the lowest point). In case of groundwater infiltration or low temperatures of the soil, the cure times must be extended.

4.3.7 Final operations

After curing, the ends of the new inner pipe shall be cut off flush with the walls of the entry and exit manholes by means of pneumatically operated cutting tools and shall be removed. In intermediate manholes, the upper half-shell of the cured-in-place pipe shall be removed down to the contact point with the manhole bottom.

At the same time, the circular samples (test rings) for the follow-on tests shall be cut from the supporting pipes and tubes, which have to be removed as well (refer to Section 7).

The cutting work shall be performed in compliance with the relevant rules and regulations of accident prevention.

4.3.8 Restoring lateral connections

Lateral connections shall be performed with the "epros®DrainLCR method" using the epros®DrainLCR hat profile" (Appendices **15** to **18**).

The resin systems of the General Technical Approvals No. Z-42.3-385 (silicate resin systems "epros®ResinType W01", "epros®ResinType W1" and "epros®ResinType S"), of the General Technical Approvals Nr. Z-42.3-466 ("epros®EPROPOX FC30") and of the General Technical Approvals No. Z-42.3-468 ("epros®HC120 and HC120+"), and "epros®EPROPOX HC60" can be used.

4.3.8.1 Resin mixture

a) The carrier material of the "epros®DrainLCR hat profile" shall be impregnated with a silicate resin mixture of the General Technical Approval No. Z-42.3-385.

The silicate resin is made up of the components A and B. One volume part of component A shall be mixed with two volume parts of component B. The resin usage amounts required for a given job shall be determined in accordance with the values shown in Tables 6. The components A and B shall be mixed in a mixing container by means of a stirring device (e.g. electrically operated mixer) in a way to ensure a bubble-free resin mixture with a homogeneous colour is obtained.

Table 6: Silicate resin usage amounts[x] for the resin systems "epros®ResinType W01", "epros®ResinType W1" and "epros®ResinType S"

Lateral connection line	**Resin system** Litres (total)[*]	**Component A** Litres	**Component B** Litres
DN 100 – 45° and 90°	0.60	0.20	0.40
DN 125 – 45° and 90°	0.75	0.25	0.50
DN 150 – 45° and 90°	0.90	0.30	0.60
DN 200 – 45° and 90°	1.20	0.40	0.80

Wall thickness: 3 mm Length: 270 mm (length within the lateral)

b) The carrier material of the "epros®DrainLCR hat profile" shall be impregnated may also be used with an epoxy resin mixture according to the General Technical Approval No. Z-42.3-466.

The epoxy resin is made up of the components A and B. The resin usage amounts required for a given job shall be determined in accordance with the values shown in Table 7. The components A and B shall be mixed in a mixing container by means of a stirring device (e.g. electrically operated mixer) such that a bubble-free resin mixture with a homogeneous colour is obtained.

Table 7**:** Epoxy resin usage amounts[x] for the resin system "epros®EPROPOX FC30"

Lateral connection line	**Resin system** Litres (total) [x)]	**Component A** Litres	**Component B** Litres
DN 100 – 45° and 90°	0.60	0.44	0.16
DN 125 – 45° and 90°	0.75	0.56	0.19
DN 150 – 45° and 90°	0.90	0.67	0.23
DN 200 – 45° and 90°	1.20	0.89	0.31

Wall thickness: 3 mm Length: 270 mm (length within the lateral)

c) The carrier material of the "epros®DrainLCR hat profile" may also be impregnated with an epoxy resin mixture according to the General Technical Approval No. Z-42.3-468.

The mixing ratio between the epoxy resin and the hardener of the resin system "epros®EPROPOX HC 120" is 100:33 Kg by weight, or 100:40 Litres by volume, and the mixing ratio of the resin system "epros®EPROPOX HC 120+" is 100:30 Kg by weight, or 100:38 Litres by volume. Once the container has been opened, the all of the hardener component must be added to the resin. A double stirrer (electrically or air-operated) shall be used to uniformly mix the hardener component with the epoxy resin without bubbles in the resin container.

d) The carrier material of the "epros®DrainLCR hat profile" may also be impregnated with an epoxy resin "epros®EPROPOX HC60".

The mixing ratio between the epoxy resin and the hardener is 100:33 Kg by weight, or 100:40 Litres by volume (Appendix **21**). Once the container has been opened, all of the hardener component must be added to the resin. A double stirrer (electrically or air-operated) shall be used to uniformly mix the hardener component with the epoxy resin without bubbles in the resin container (cf. Section 4.3.5 a)).

The resin mixture as well as the temperature conditions shall be recorded in the report according to Section 4.3.1.

A sample shall be taken from each mixed resin batch to verify and report its reactivity.

4.3.8.1 Installation of hat profiles

The main/lateral interfaces masked by the inverted liner shall be cut open from the inside of the cured-in-place polyester needle felt tube.

Lateral connections of the sizes DN 100 to DN 200 shall be restored from the main sewer line of the sizes DN 100 to DN 250 by means of the lining device ("epros®DrainLCR packer") according to Appendix **15** and the "epros®DrainLCR hat profile" in connection with the components, equipment and installations specified in Section 4.2.2.

The lining device is composed of a preformed cylindrical inflatable packer body and a lateral tube centrally located on the side surface at an angle of 45 degrees or 90 degrees. The packer body runs on two mounted telescoping-style wheel systems. The "epros®DrainLCR hat profile" is designed as a cap or hat to be put onto the lateral tube of the "epros®DrainLCR packer". Then the lateral tube of the "epros®DrainLCR packer" with the "epros®DrainLCR hat profile" in place shall be retracted into the packer body to allow the packer to be introduced and moved down the host pipe.

The "epros®DrainLCR hat profile" wetted both sides with silicate resin shall be pushed with the packer down the pipe to the point of repair by means of locking push rods (variant a) or a carriage (variant b). A camera shall be fitted to the packer for proper positioning. Once the packer is in place, compressed air shall be applied to the packer body to cause the lateral tube with the "epros®DrainLCR hat profile" to be inverted down into the lateral connection pipe. It is important to ensure that the "epros®DrainLCR hat profile" part to be introduced into the lateral connection line will cover the first pipe joint of the lateral and that the transition zones with the host pipe and with the cured-in-place new pipe are formed with no steps or wrinkles that might impair the hydraulic capacity. The pressure applied to the packer body with its lateral extension will be maintained until the resin mixture has hardened completely.

The curing time for the "epros®DrainLCR hat profile" (see Table 5 and Tables 8 to 11) varies according to the resin system selected and depends on the mixing ratio of the components A and B as shown in Section 4.8.3.1, as well as on the prevailing ambient temperatures. The curing time and the applied pressure shall be recorded. After complete cure, the packer shall be deflated and withdrawn from the sewer.

Table 8: Curing times and mixing ratio of components A and B" "epros®ResinType W" and "epros®ResinType S"

Mixing ratio by volume				Pot time at +20°C min	Curing time at +15°C min
No.	**Comp. A Hardener**	**Comp. B "epros® Resin Type W"**	**Comp. B "epros® Resin Type S"**		
1	3	6	—	15	115
2	3	5	1	18	120
3	3	4	2	21	140
4	3	3	3	25	165
5	3	2	4	28	180
6	3	1	5	31	200
7	3	—	6	32	260

Table 9: Curing times and mixing ratio of components A and B "epros®ResinType W01"

Mixing ratio by volume			Pot time at +10°C min	Pot time at +22°C min	Curing time at +12°C min	Curing time at +20°C min
No.	Comp. A Hardener	Comp. B "epros®Resin Type W01"				
1	1	2	13-15	4.5-7.5	35	20

Table 10: Curing times of the epoxy resin system "epros®EPROPOX FC30"*

Curing time in minutes	Curing temperatures
approx. 600	at +10°C
approx. 360	at +15°C
approx. 240	at +20°C
approx. 150	at +25°C

* Curing times (heating phase without cooling-down phase) of the resin system for ambient, hot water and steam cure up to a max. heating flow temperature of **+40°C**

Table 11: Curing times of the epoxy resin system "epros®EPROPOX HC120 and HC120+"

Curing time in minutes	Curing temperatures
approx. 1,140	at +10°C
approx. 90	at +60°C for hot water circulation
approx. 45	at +80°C for hot water circulation
approx. 45	at +80°C for steam

The curing times for the "epros®EPROPOX HC60" resin system are given in Table 5.

If there are larger amounts of residual resin from installation and curing, the installer must remove them from the sewer line; smaller amounts of waste resin can be neglected.

The waterproof reconnection of lateral pipes can also be performed with other rehabilitation methods under valid general technical approvals. Open construction is possible as well.

4.3.9 Pipe-to-manhole connection

Waterproof pipe-to-manhole connections shall be sealed with swelling tapes (Appendix **20**) to be positioned at the pipe-to-manhole interfaces before the PE preliner is installed.

In the entry manhole and, if required, also in the exit manhole, as well as in intermediate manholes, both the cured-in-place pipe portions protruding from the face wall into the manhole (see also Section 4.3.7 Final operations) and the transition zones with the invert at the entry and exit manhole bottoms shall be made watertight.

Where it is not possible to use swelling tapes (auxiliary tapes), the waterproof connection between the liner and the manhole wall can be made in any of the following ways after the liner is cured:

a) Liner-to-manhole connection by application of a reaction resin having a valid general technical approval;
b) Liner-to-manhole connection by application of grout systems having a valid general technical approval;
c) GRP laminates;
d) Pressure injection of polyurethane (PU) or epoxy (EP) resins having a valid general technical approval;
e) Installation of liner end sleeves having a valid general technical approval.

It is important to ensure proper execution of the sealing work for watertight transitions in good workmanship.

5 Job data in the manhole

The following job data should be indicated by means of a permanent and readily legible inscription in the entry manhole or exit manhole of the CIPP job:

– Type of rehabilitation
– Designation of the pipe section
– Nominal diameter
– Wall thickness of the liner
– Year the work was done

6 Final inspection and tightness test

After completion of the work, the relined pipe run shall undergo optical inspection as proof there is no residual waste material left in the line and no wrinkles impairing the hydraulic capacity.

After final cure of the liner including reconnection of the laterals, the sewer line shall be subjected to a tightness test including, where appropriate, the pipe-to-manhole connections. Such test may be performed section by section.

The tightness test for the relined pipes shall be performed with water method “W” (see Appendix **32**) or air method “L” according to DIN EN 1610[15]. The air tightness test shall observe the specifications contained in Table 3 of DIN EN 1610[15], LD test method for moist concrete pipes and all other materials. The relined main-to-lateral interfaces can be subjected to a separate water tightness test by means of suitable inflatable pipe plugs or stop discs.

7 Testing of samples

7.1 General

Rings or segments shall be taken as samples from the cured circular liners on the job site (delivery note in Appendix **33**). Should the specimens be found to be unsuitable for the tests mentioned at 7.2.1, or should it be impossible to take any ring or segment samples, an alternative DSC analysis according to Section 7.2.2 can be made for lateral liners up to DN 200.

Samples shall be taken from the sewer line on the job site for the analysis of the characteristic material properties by means of the differential scanning calorimetry (DSC). The samples shall be core samples to be drilled with a diameter of no less than 2.5 cm.

15 DIN EN 1610 Construction and testing of drains and sewers; German version EN 1610:1997; issue: 1997-10 in connection with DIN EN 1610 Supplement 1; issue:1997-10

7.2 Strength properties

7.2.1 Determination of strength properties by means of the three-point bending test and long-term ultimate ring deflection test

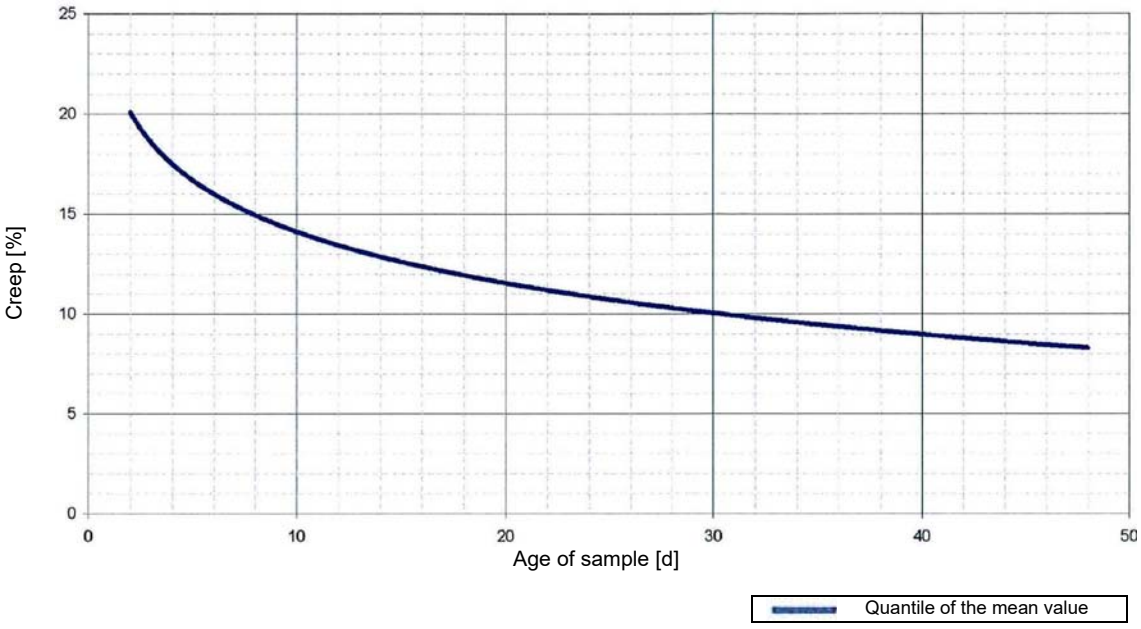
The samples shall be tested for their flexural modulus and flexural stress σ_{fB}.

The initial value, the 1-hour value and the 24-hour value of the flexural modulus and the initial value of the flexural stress σ_{fB} shall be recorded. The test shall also show whether the creep value after DIN EN ISO 899-2[16] is observed according to the following formula or according to Chart **1**:

$$K_n = \frac{E_{1h} - E_{24h}}{E_{1h}} \; x \; 100$$

Creep behaviour depends on the amount of subsequent cross-linkage of the resin and can thus be seen from Chart **1** according to the age of the sample.

Chart **1**: "Assessment of creep as a function of sample age"



The creep behaviour determined in the test on the sample taken on the job site shall not exceed the age-related creep value shown in Chart **1**.

Also, the flexural modulus and the flexural stress σ_{fB} according to DIN EN ISO 178[9] (three-point bending test) shall be determined on the cured liner. The specimens used in the tests shall be curved rods cut from the appropriate circular section with a minimum width of 50 mm in radial direction. The testing and calculation of the modulus of elasticity must take into account the span measured between the supporting points of the test rod.

The initial values determined for the modulus and flexural stress σ_{fB} shall be equal to or greater than the value mentioned in Section 9.

16 DIN EN ISO 899-2 Plastics – Determination of creep behaviour – Part 2 Flexural creep by three-point loading (ISO 899-2:2003); German version EN ISO 899-2:2003; issue:2003-10

Additionally, test rings shall be tested for their initial value, 1-hour value and 24-hour value of ring stiffness when a new resin supplier is used. Ring stiffness tests shall conform to the standard test method laid down in DIN 53769-3[17]. Also, creep shall be tested.

7.2.2 Determination of strength properties by means of DSC analysis for lateral liners up to DN 200

If it is not possible to take circular ring samples or segments, an alternative option for lateral liners up to DN 200 is to make a DSC analysis of the samples taken on the job site.

The following procedure shall be complied with:

1. Cutting through the drilled core sample (diamond cut)
2. Measuring the wall thickness of the structural layer in three points
3. Qualitative assessment of the structural layer in the sawn region according to DIN 18820-3[18] Section 5.2
4. Preparation of specimen for DSC analysis
5. DSC analysis according to DIN 53765[19], Method A-20
6. Evaluation of test results according to Section 9

7.3 Water tightness of the samples

The water tightness of the cured liner with integrated PP film of variant f) of the "epros®SteamLiner" can be tested either on a circular liner sample (test ring) with PP coating or on sample specimens taken from the cured PP-coated liner.

The water tightness of the cured liner of the variants a) to e) (PVC, PP, SK or PUR films) of the "epros®DrainLiner" "epros®DrainFlexLiner" and "epros®DrainPlusLiner" can be tested either on a circular liner sample (test ring) without film coating or on specimens taken from the cured liner without film coating. For testing, the coating film of the liner sample or specimen shall be either removed or perforated. Care shall be taken to avoid damage to the structural layer.

The test on specimens may use either a positive or a negative pressure of 0.5 bar.

For the negative pressure test, water shall be supplied to one end of the specimen. No visible leakage of water shall occur at the opposite end of the specimen during a load period of 30 minutes.

In the positive pressure test, a water pressure of 0.5 bar shall be applied and held for a period of 30 minutes. Again, there shall be no visible leakage at the opposite end of the specimen.

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17 DIN 53769 Testing of glass fibre reinforced plastic pipes; determination of short-term and long-term ring stiffness; issue: 1988-11

18 DIN 18820-3 Glass fibre reinforced unsaturated polyester (GF-UP) and phenacrylic (GF-PHA) resin structural composites; Protection for structural layer; issue:1991-03

19 DIN 53765 Testing of plastics and elastomers; Thermal analysis; Differential Scanning Calorimetry (DSC); issue:1994-03

7.4 Wall structure

The wall structure according to the conditions specified in Section 2.1.3 shall be verified by examining cut edges with a light microscope having a magnification power of approx. 10X. Also, the average area percentage occupied by air bubbles shall be determined according to DIN EN ISO 7822[20].

7.5 Physical characteristics of the cured liner

The samples taken shall be tested for the characteristics mentioned at Section 2.1.4.

8 Declaration of Compliance for the performed lining job

The installing company must certify that the performed relining job is in compliance with the provisions laid down in this General Technical Approval by issuing a Declaration of Compliance based on the specifications in Table 12 and Table 13. Said Declaration of Compliance shall be accompanied by documents showing the properties of the method components mentioned at Section 2.1.1 and by the results of the tests mentioned in Table 12 and Table 13.

The lining job manager or a technically competent representative of the job manager shall be present on the job site during the performance of the ling operation. This person shall see to the proper execution of the work according to the provisions laid down in Section 4 and, more specifically, shall perform or arrange for the tests specified in Table 12 and shall arrange for the tests specified in Table 13. The specified number of tests and scope of testing shall be minimum requirements.

The tests on specimens according to Table 13 shall be carried out by an accredited inspection body (refer to the List of Inspection, Control and Certification Bodies under the Building Codes of the German Länder, Part V, No. 9).

Once every six months, the aforesaid inspection body shall take a sample from a CIPP liner of a completed lining job. Also, this body shall inspect the documentation of the tests performed according to Table 12 for the same lining job.

[20] DIN EN ISO 7822 Textile glass reinforced plastics -- Determination of void content -- Loss on ignition, mechanical disintegration and statistical counting methods (ISO 7822:1990); German version EN ISO 7822:1999, issue: 2000-01

Table 12: Tests to be carried out during operation

Test object	Type of requirement	Testing interval
Optical inspection of the line	according to 4.3.1 and ATV-M 149-2[12]	before each lining operation
Optical inspection of the line	according to 6 and ATV-M 149-2[12]	after each lining operation
Equipment	according to 4.2	each job site
Identification of containers of lining components	according to 2.2.3	
Air or water tightness	according to 6	
Resin mixture, resin amount & cure behaviour for each liner tube	mixing report according to 4.3.5	
Curing temperature and curing time	according to 4.3.6.4	
Analysis of glass transition temperatures T_{G1} and T_{G2} by means of DSC[1] for lateral liners up to DN 200	according to 2.1.2.3 and 7.2.2 (alternative)	

1) If the DSC analysis finds the job-site samples to meet the glass transition temperatures T_{G1} and T_{G2} mentioned at Section 2.1.2.3, this result shall be deemed appropriate proof of compliance with the physical characteristics of the cured polyester/resin composite as specified in Section 2.1.2.2.

The lining job manager or the technically competent representative of the job manager shall arrange for the tests mentioned in Table 13. The samples for the tests mentioned in Table 13 shall be taken from the described sample tubes.

Table **13**: Tests to be carried out on specimens

Test object	Type of requirement	Testing interval
Initial flexural modulus and initial flexural stress σ_{fB} and creep behaviour on pipe segments or rings, or DSC analysis for lateral liners up to DN 200	according to 7.1 and 7.2.1 according to 2.1.2.3 and 7.2.2	each job site, at least every second liner
Density of sample without preliner and without coating film	according to 2.1.2.2	
Water tightness of the sample of the variants a) to e) without preliner and without PVC, PP or PUR film; of the sample of the variant f) without preliner but with the PP film	according to 7.3	
Wall structure	according to 7.4	
Resin identity by means of IR spectroscopy	according to 2.1.1	each time there is a new resin supplier with declaration of resins
Initial modulus of elasticity (initial ring stiffness) and creep behaviour on pipe segments or rings	according to 2.1.2.2 and 7.2.1	each time there is a new resin supplier with declaration of resins
Creep behaviour on pipe segments or rings	according to 7.2.1	if value falls below the initial modulus of elasticity mentioned at Section 9, and at least 1 liner every six months

The test results shall be recorded and evaluated; they shall be submitted to the German Institute for Construction Engineering when so requested. The number and scope of testing given in the tables shall be minimum requirements.

9 Provisions for dimensioning

If structural design calculations are required for a given lining job, appropriate proof of the structural stability of the liner system shall be furnished according to the Worksheet DWA-A 143-2[5] of the German Association for Water, Wastewater and Waste (DWA) before the lining operations are started.

The structural design calculation shall include a safety coefficient of γ_M = 1.35 for the liner tube material.

The reduction factor A for long-term values according to the 10,000-hour test (after DIN EN 761[21]) is A = 2.21.

[21] DIN EN 761 Plastics piping systems – Glass-reinforced thermosetting plastics (GRP) pipes – Determination of the creep factor under dry conditions; German version EN 761:1994; issue:1994-08

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The following values shall be taken into account for the structural design calculations:

- Initial flexural stresses σ_{fB} after DIN EN ISO 178[9]: 60 N/mm²
- Long-term flexural stresses σ_{fB}: 27 N/mm²
- Initial circumferential modulus of elasticity after DIN EN 1228[6]: 2,700 N/mm²
- Long-term circumferential modulus of elasticity: 1,220 N/mm²

Rudolf Kersten
Head of Unit

Attested
[signature and DIBt stamp]

Liner Cross-Sections

1 Host pipe

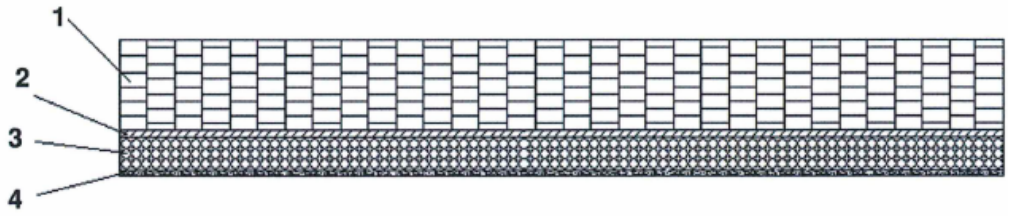
2 Preliner

3 Cured impregnated DrainLiner, DrainFlexLiner, DrainSteamLiner, DrainPlusLiner (PUR/1.0/2.0)

4a	for epros®DrainLiner	DN 100-DN 400 – PVC coating	(thickness: 0.40–0.50 mm)
4b	for epros®DrainLiner	DN 100-DN 400 – PP coating	(thickness: 0.30–0.40 mm)
4c	for epros®DrainFlexLiner	DN 100-DN 400 – PP coating	(thickness: 0.30–0.40 mm)
4d	for epros®DrainPlusLiner	DN 100-DN 250 – PUR coating	(thickness: 0.20–0.25 mm)
4e	for epros®DrainPlusLiner	DN 100-DN 250 – silicone coating	(thickness: 0.45–0.75 mm)
4f	for epros®DrainSteamLiner	DN 100-DN 400 – PP coating	(thickness: 0.40–0.60 mm)

The coatings of variants **4a** to **4e** are used as an installation aid for the tube liner.

The PP coating of variant **4f** “DrainSteamLiner” is an integrated component part of the tube liner.



“DrainLiner method” with “EPROPOX HC60” resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 1
DrainLiner Method Liner tube cross sections	

Table A: DrainLiner PVC / PP, properties prior to installation

Nominal diameter	Final wall thickness	Initial wall thickness	Mass per unit area (w/o coating)	Liner overall weight including seam/coating 300 µm	Liner overall weight including seam/coating 500 µm	Liner overall weight including seam/coating 600 µm	Maximum deviation
DN	mm	mm	g/m²	g/lm	g/lm	g/lm	+/- %
100	3	>3,0	650	303	360	388	15
100	4,5	>4,5	900	374	431	459	15
125	3	>3,0	650	371	441	477	15
125	4,5	>4,5	900	459	530	565	15
150	3	>3,0	650	438	522	565	15
150	4,5	>4,5	900	544	628	671	15
150	6	>6,0	1200	671	756	798	15
200	3	>3,0	650	572	685	742	15
200	4,5	>4,5	900	713	826	883	15
200	6	>6,0	1200	883	996	1052	15
225	3	>3,0	650	639	766	830	15
225	4,5	>4,5	900	798	925	989	15
225	6	>6,0	1200	989	1116	1180	15
250	3	>3,0	650	706	847	918	15
250	4,5	>4,5	900	883	1024	1095	15
250	6	>6,0	1200	1095	1236	1307	15
300	3	>3,0	650	840	1010	1095	15
300	4,5	>4,5	900	1052	1222	1307	15
300	6	>6,0	1200	1307	1476	1561	15
300	7,5	>7,5	1500	1561	1731	1815	15
300	9	>9,0	1800	1815	1985	2070	15
300	10,5	>10,5	2100	2070	2239	2324	15
300	12	>12,0	2400	2324	2494	2578	15
350	3	>3,0	650	975	1172	1271	15
350	4,5	>4,5	900	1222	1420	1519	15
350	6	>6,0	1200	1519	1716	1815	15
350	7,5	>7,5	1500	1815	2013	2112	15
350	9	>9,0	1800	2112	2310	2409	15
350	10,5	>10,5	2100	2409	2607	2706	15
350	12	>12,0	2400	2706	2903	3002	15
400	4,5	>4,5	900	1391	1618	1731	15
400	6	>6,0	1200	1731	1957	2070	15
400	7,5	>7,5	1500	2070	2296	2409	15
400	9	>9,0	1800	2409	2635	2748	15
400	10,5	>10,5	2100	2748	2974	3087	15
400	12	>12,0	2400	3087	3313	3426	15

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 2
DrainLiner Method DrainLiner PVC/PP; properties prior to installation	

Table B: DrainFlexLiner / DrainSteamLiner PP, properties prior to installation

Nominal diameter	Final wall thickness	Initial wall thickness	Mass per unit area (w/o coating)	Liner overall weight including seam/coating 300 µm	Liner overall weight including seam/coating 500 µm	Liner overall weight including seam/coating 600 µm	Maximum deviation
DN	mm	mm	g/m²	g/lm	g/lm	g/lm	+/- %
100	3	>3,0	650	303	360	388	15
100	4,5	>4,5	900	374	431	459	15
125	3	>3,0	650	371	441	477	15
125	4,5	>4,5	900	459	530	565	15
150	3	>3,0	650	438	522	565	15
150	4,5	>4,5	900	544	628	671	15
150	6	>6,0	1200	671	756	798	15
200	3	>3,0	650	572	685	742	15
200	4,5	>4,5	900	713	826	883	15
200	6	>6,0	1200	883	996	1052	15
225	3	>3,0	650	639	766	830	15
225	4,5	>4,5	900	798	925	989	15
225	6	>6,0	1200	989	1116	1180	15
250	3	>3,0	650	706	847	918	15
250	4,5	>4,5	900	883	1024	1095	15
250	6	>6,0	1200	1095	1236	1307	15
300	3	>3,0	650	840	1010	1095	15
300	4,5	>4,5	900	1052	1222	1307	15
300	6	>6,0	1200	1307	1476	1561	15
300	7,5	>7,5	1500	1561	1731	1815	15
300	9	>9,0	1800	1815	1985	2070	15
300	10,5	>10,5	2100	2070	2239	2324	15
300	12	>12,0	2400	2324	2494	2578	15
350	3	>3,0	650	975	1172	1271	15
350	4,5	>4,5	900	1222	1420	1519	15
350	6	>6,0	1200	1519	1716	1815	15
350	7,5	>7,5	1500	1815	2013	2112	15
350	9	>9,0	1800	2112	2310	2409	15
350	10,5	>10,5	2100	2409	2607	2706	15
350	12	>12,0	2400	2706	2903	3002	15
400	4,5	>4,5	900	1391	1618	1731	15
400	6	>6,0	1200	1731	1957	2070	15
400	7,5	>7,5	1500	2070	2296	2409	15
400	9	>9,0	1800	2409	2635	2748	15
400	10,5	>10,5	2100	2748	2974	3087	15
400	12	>12,0	2400	3087	3313	3426	15

Table C: DrainPlusLiner at 9% undersize, properties prior to installation

Nominal diameter	Final wall thickness	Initial wall thick-ness	Mass per unit area (without coating)	Liner total weight incl. seam and coating	Maximum deviation
DN	mm	mm	g/m²	g/m	± %
100	3	>3.0	416	198	15
125	3	>3.0	416	244	15
150	3	>3.0	416	290	15
200	3	>3.0	416	381	15
225	3	>3.0	416	427	15
250	3	>3.0	416	473	15

Table D: DrainPlusLiner at 18% undersize, properties prior to installation

Nominal diameter	Final wall thick-ness	Initial wall thick-ness	Mass per unit area (without coating)	Liner total weight incl. seam and coating	Maximum deviation
DN	mm	mm	g/m²	g/m	± %
100	3	>3.0	416	180	15
125	3	>3.0	416	221	15
150	3	>3.0	416	263	15
200	3	>3.0	416	345	15
225	3	>3.0	416	386	15
250	3	>3.0	416	428	15

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 4
DrainLiner Method DrainPlusLiner at 9% and 18% undersize; properties prior to installation	

Table E: DrainPlusLiner 1.0 at 10% undersize, properties prior to installation

Nominal diameter	Final wall thick-ness	Initial wall thick-ness	Mass per unit area (without coating)	Liner total weight incl. seam and coating	Maximum deviation
DN	mm	mm	g/m²	g/m	± %
100	>3.0	>4.0	650	434	15
125	>3.0	>4.0	650	542	15
150	>3.0	>4.0	650	650	15
200	>3.0	>4.0	650	867	15
225	>3.0	>4.0	650	975	15
250	>3.0	>4.0	650	1084	15

Table F: DrainPlusLiner 2.0 at 10% undersize, properties prior to installation

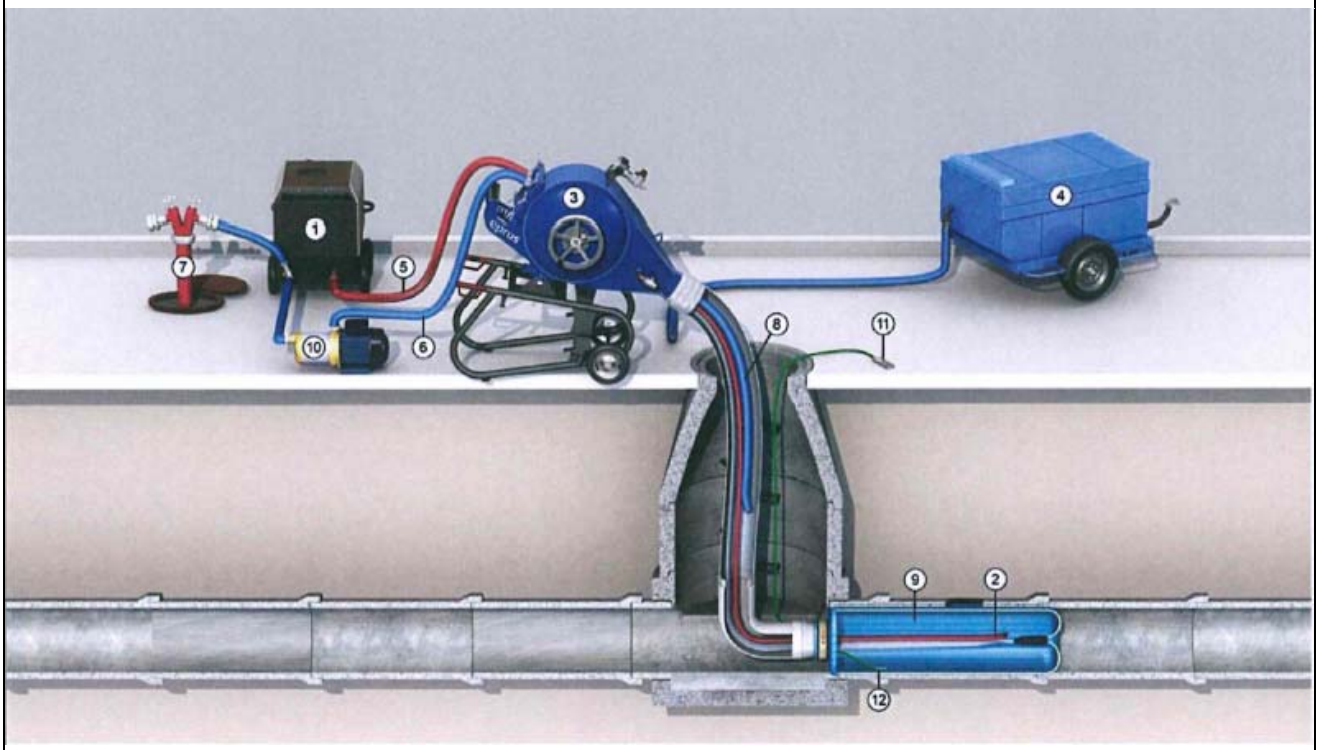
Nominal diameter	Final wall thick-ness	Initial wall thick-ness	Mass per unit area (without coating)	Liner total weight incl. seam and coating	Maximum deviation
DN	mm	mm	g/m²	g/m	± %
100	>4.0	>5.0	800	481	15
125	>4.0	>5.0	800	601	15
150	>4.0	>5.0	800	721	15
200	>4.0	>5.0	800	961	15
225	>4.0	>5.0	800	1081	15
250	>4.0	>5.0	800	1202	15

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 5
DrainLiner Method DrainPlusLiner 1.0/2.0 with silicone coating and 10% undersize Properties prior to installation	

VARIANT 1:

Hot Water Cure with Circulation
System Layout

Item	Description
1	HotBox
2	Flat hose for hot water circulation or push hose
3	InversionDrum or inversion air lock
4	Air supply
5	Hot-water flow line
6	Cold-water return line
7	Water supply
8	Circulation line suction hose or push hose
9	DrainLiner
10	Circulation pump

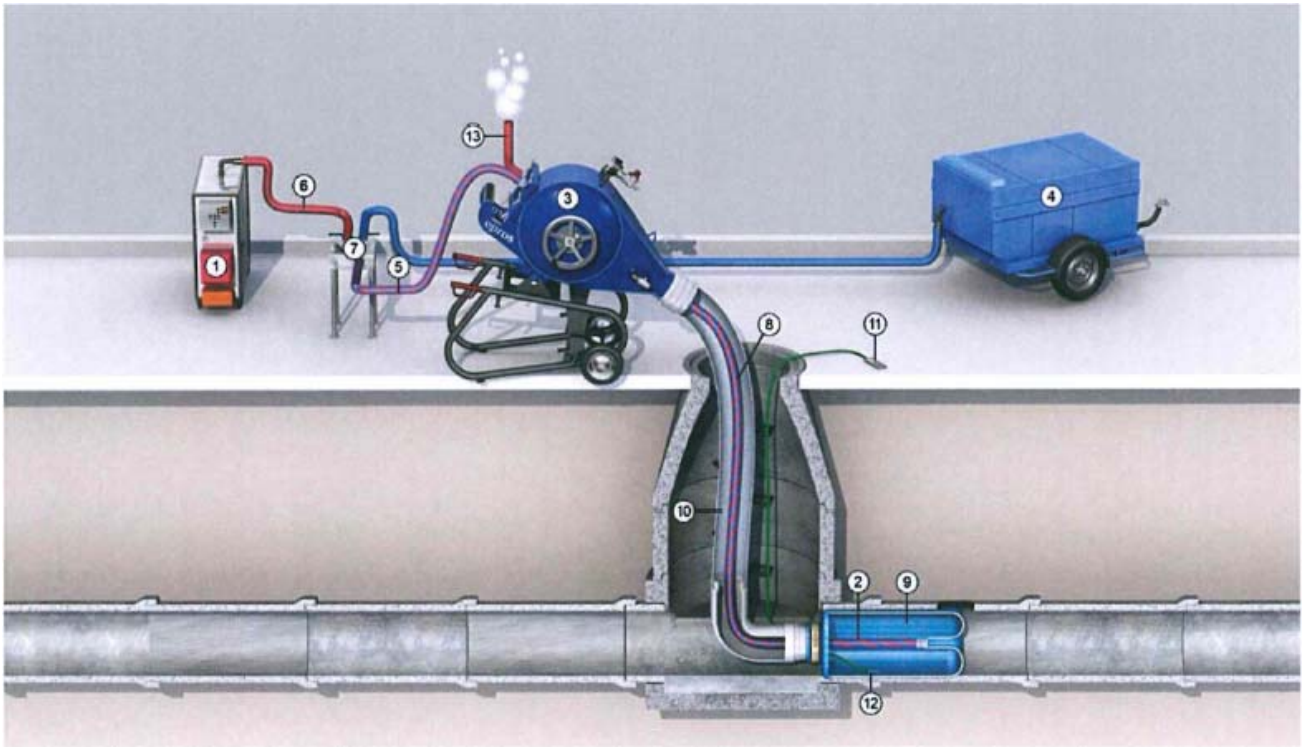


"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 6
VARIANT 1 Hot-water cure with circulation	

VARIANT 2:

Steam Cure with Heating Hose
System Layout

Item	Description
1	SteamGen steam generator
2	Control tape
3	InversionDrum or inversion airlock
4	Air supply
5	Steam/air feed line
6	Steam line
7	SteamTelemetry unit
8	Heating hose
9	DrainLiner
10	Inversion hose, resistant to steam
11	Temperature measuring system
12	Temperature measuring point in the invert
13	Steam outlet hose

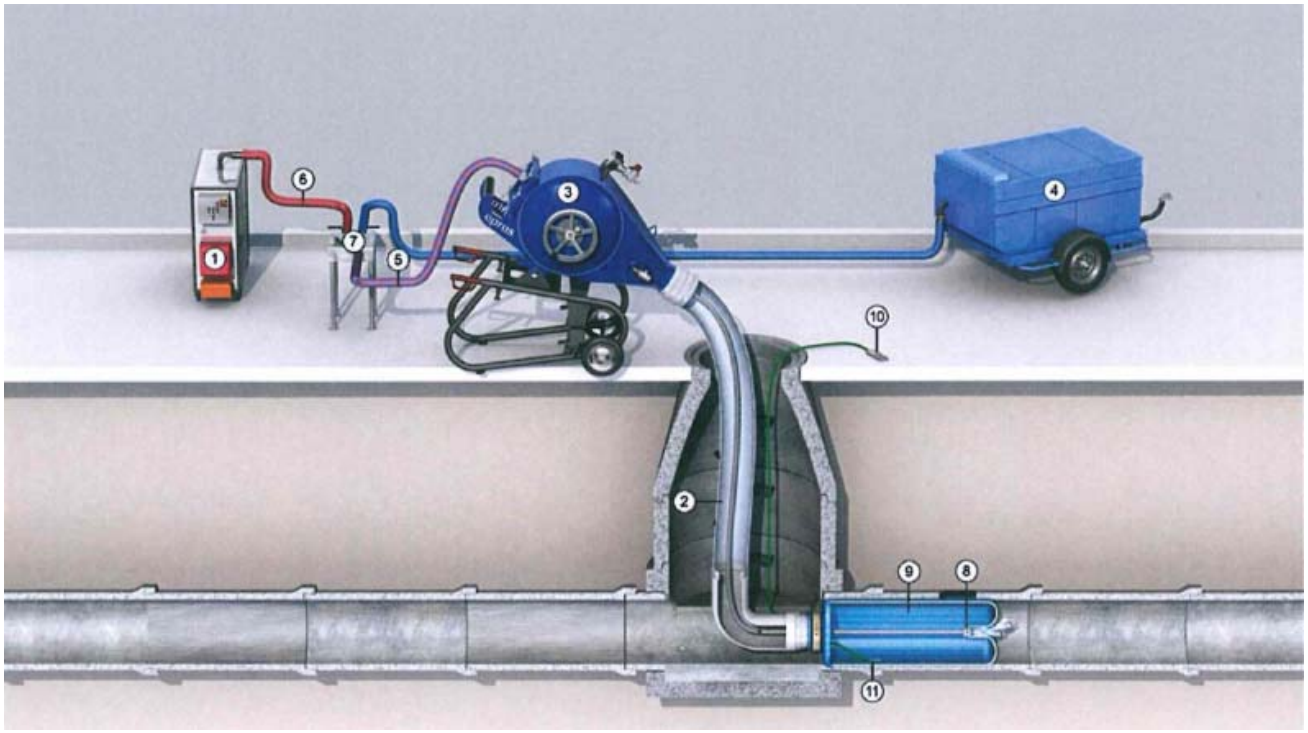


"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 7
VARIANT 2 Steam cure with heating hose	

VARIANT 3:

Steam Cure with Steam Outlet Valve
System Layout

Item	Description
1	SteamGen steam generator
2	Control tape
3	InversionDrum or inversion airlock
4	Air supply
5	Steam/air feed line
6	Steam line
7	SteamTelemetry unit
8	epros®SteamGen steam outlet valve
9	DrainLiner
10	Temperature measuring system
11	Temperature measuring point in the invert



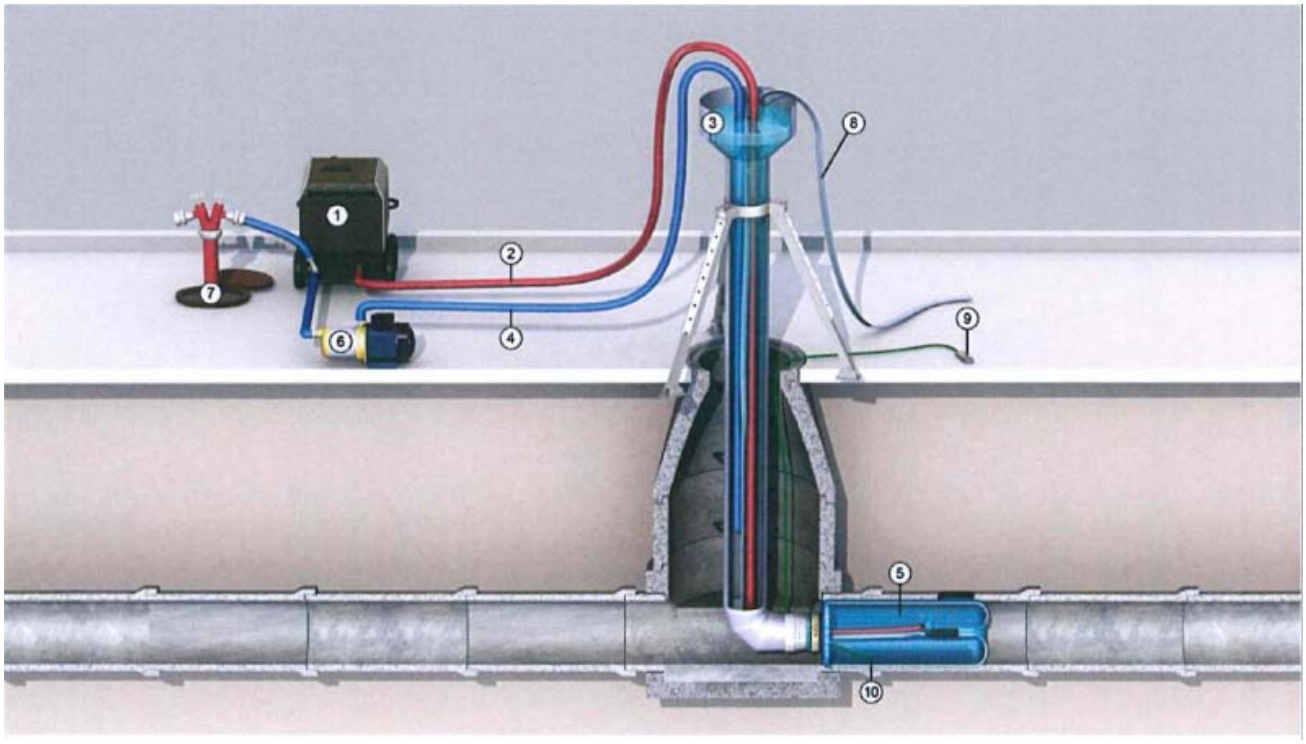
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 8
VARIANT 3 Steam cure with steam outlet valve	

VARIANT 4:

"Water Column" Inversion with Hot Water Cure

System Layout

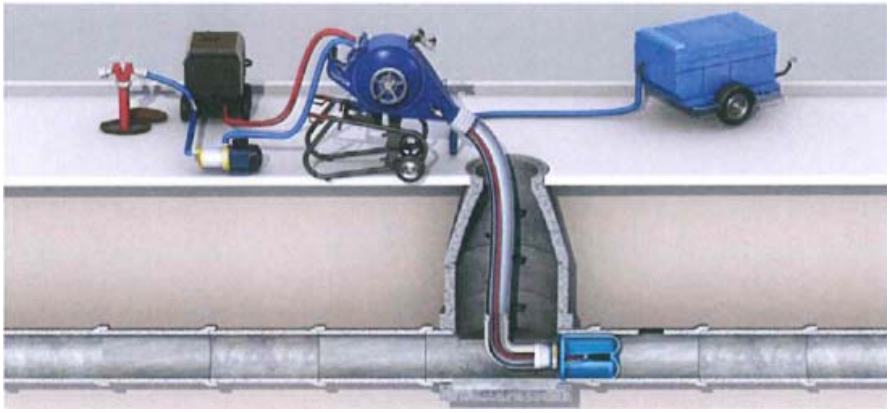
Item	Description
1	HotBox
2	Hot water circulation (flat) hose
3	Inversion pipe
4	Circulation line suction hose, return line
5	DrainLiner
6	Circulation pump
7	Water supply
8	Control tape
9	Temperature measuring system
10	Temperature measuring point in invert



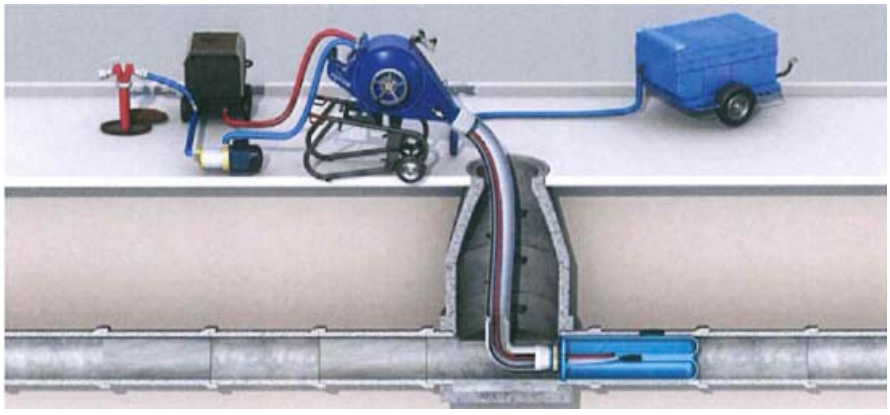
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 9
VARIANT 4 Water inversion with hot water cure	

Hot Cure with Circulation/Steam Outlet Valve

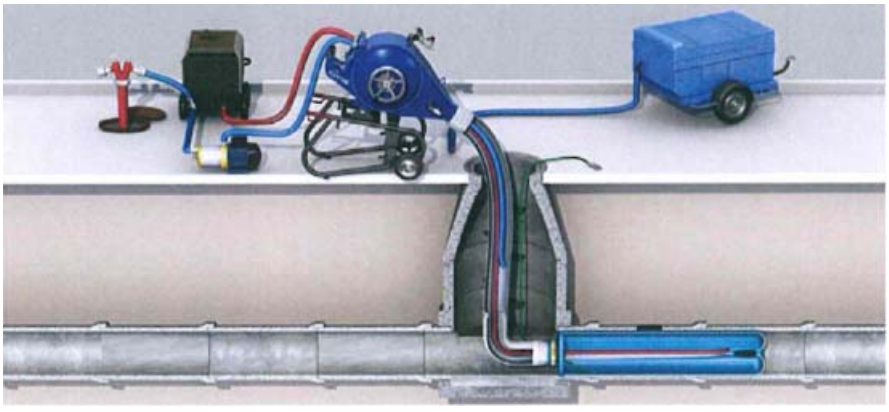
Closed-End Method



1. Position the liner tube at the starting point; fix the control tape and the heating hose



2. Invert the liner tube together with the heating hose

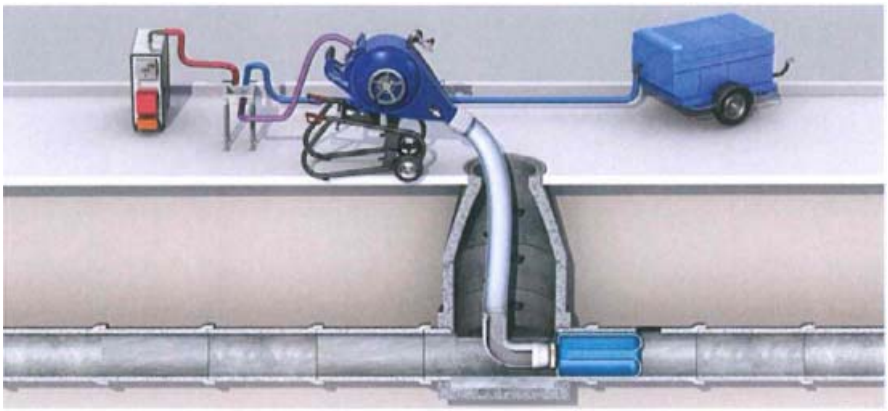


3. Hot cure. The fluid flows to the end of the liner tube and returns within the liner. Alternative option: When a steam outlet valve is used, the steam/air mixture flows in inversion direction and exits at the head of the liner.

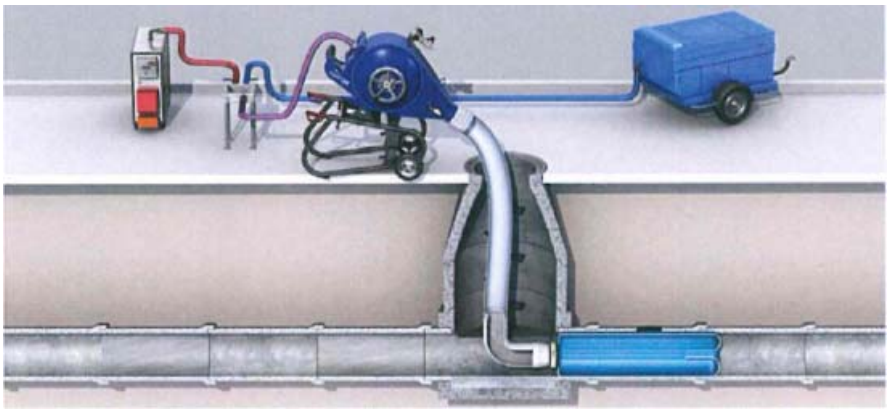
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 10
Rehabilitation with closed liner end Closed-End Method	

Hot Cure with Circulation/Steam Outlet Valve 1 of 2

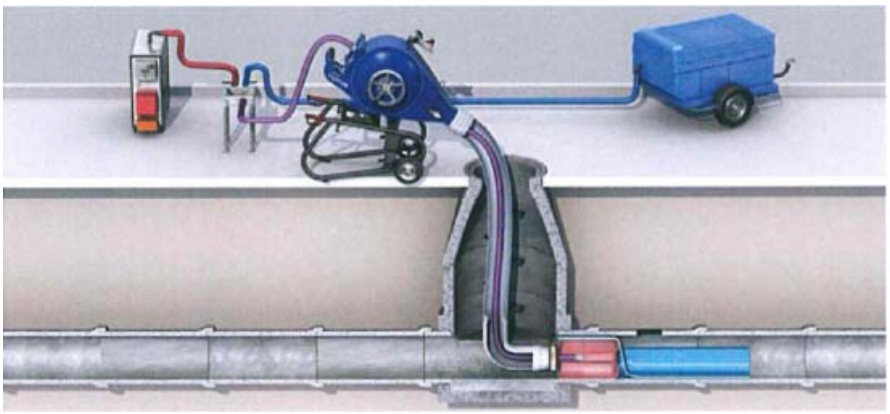
Open-End Method, subsequent inversion of calibration hose



1. Position the liner tube at the starting point



2. Invert the open-ended liner tube

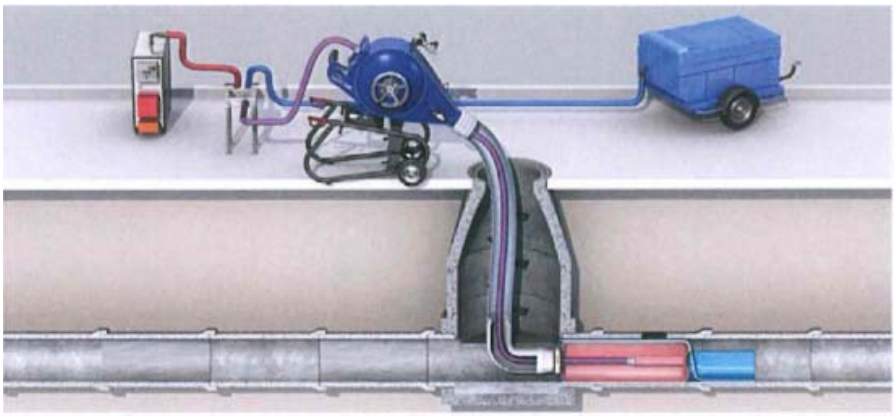


3. Remove the liner tube from the inversion fitting, introduce the calibration hose and position it at the starting point

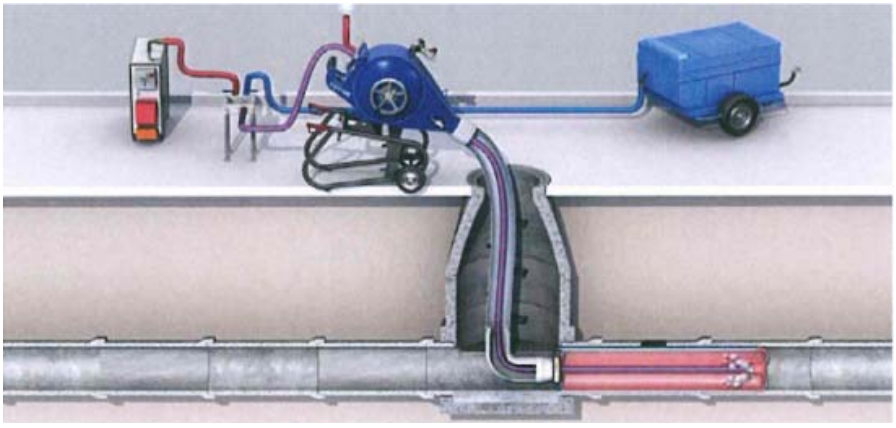
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 11
Rehabilitation with open liner end, subsequent inversion of calibration hose Open-End Method 1 of 2	

Hot Cure with Circulation/Steam Outlet Valve 2 of 2

Open-End Method, subsequent inversion of calibration hose



4. Invert the calibration hose into the liner tube. For circulation, invert also the heating hose; otherwise fix the steam outlet valve to the head end of the calibration hose.

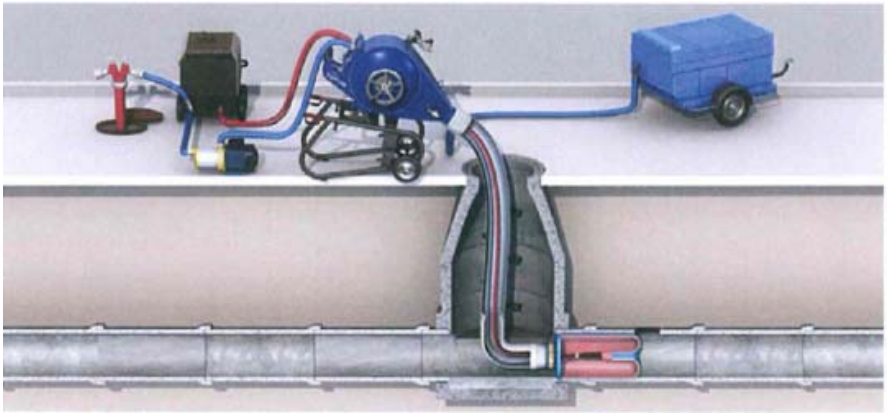


5. Curing with calibration hose. The hot fluid is passed to the liner head and returns inside the liner tube.
   Alternative option: With the steam outlet valve, the steam/air mixture flows in the inversion direction and exits the head of the liner.

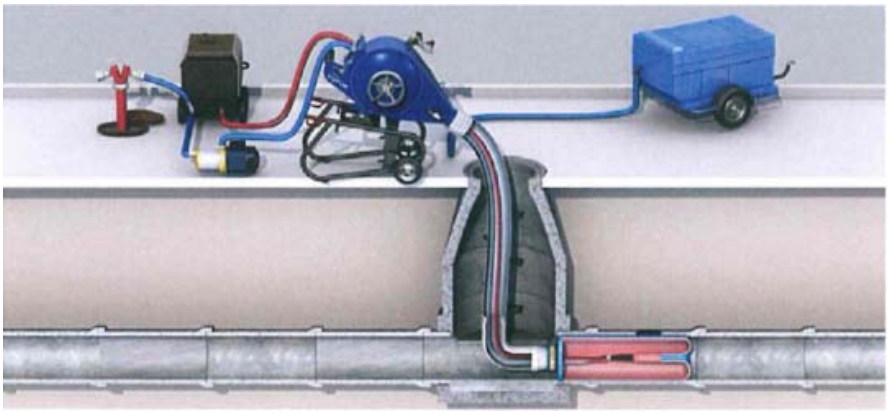
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 12
Rehabilitation with open liner end, subsequent inversion of calibration hose Open-End Method 2 of 2	

Hot Cure with Circulation (Water or Steam)

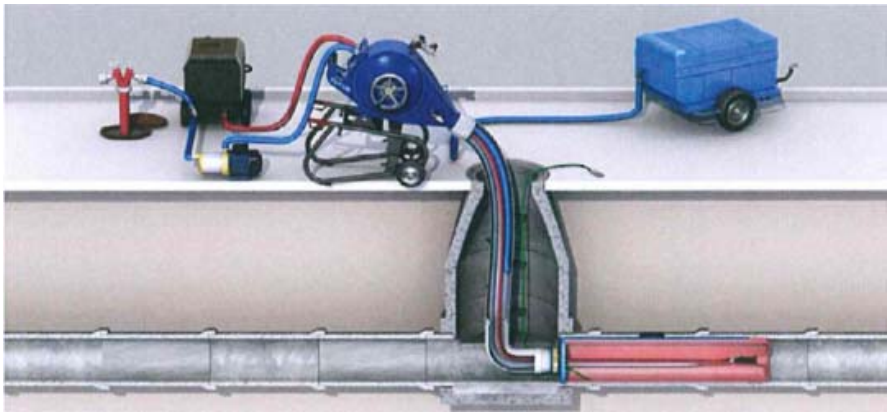
Open-End Method, simultaneous inversion of calibration hose



1. Position the liner tube with calibration hose at the starting point



2. Invert the liner tube simultaneously with the calibration hose

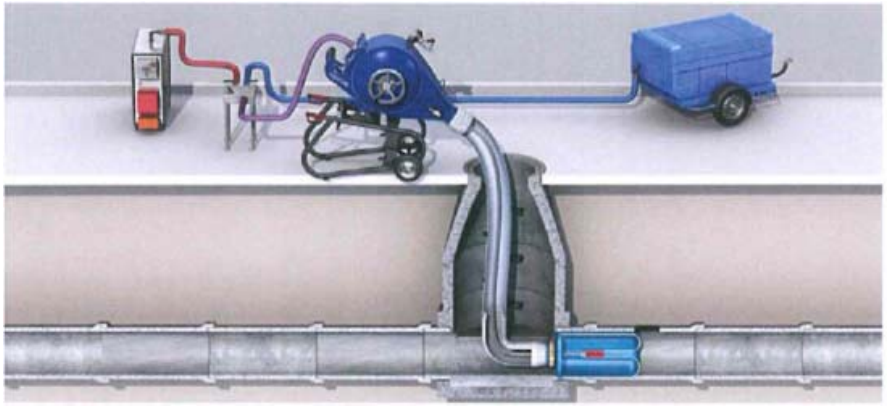


3. Curing with calibration hose. The hot fluid is passed to the liner head and returns inside the liner tube.
   Alternative: With the steam outlet valve, the steam/air mixture flows in inversion direction in the liner and exits the head of the liner.

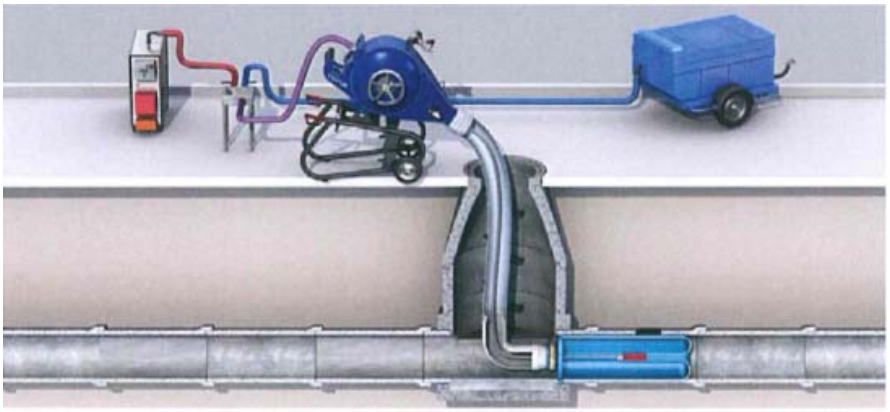
"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 13
Rehabilitation with open liner end, simultaneous inversion of calibration hose Open-End Method	

Hot Cure with Circulation/Steam Outlet Valve

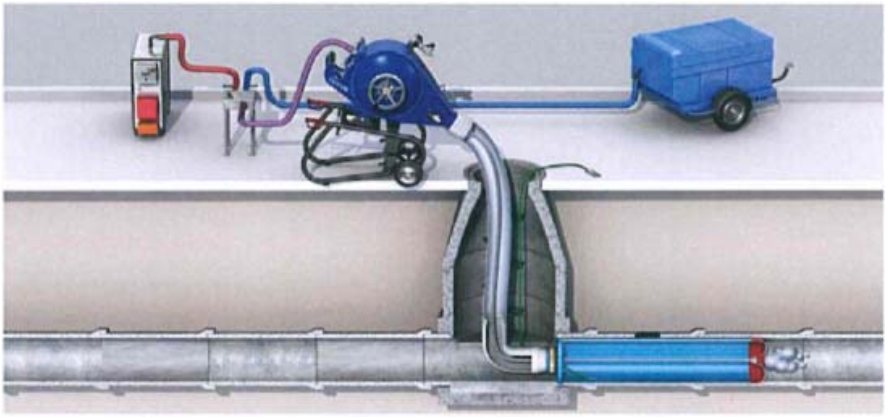
Open-End Method with epros®LinerEndCap



1. Position the liner tube with calibration hose at the starting point



2. Invert the liner tube with the epros®LinerEndCap



3. Curing with calibration hose, hot fluid is passed to the liner head and returns inside the liner tube.
   Alternative option: With the steam outlet valve, the steam/air mixture flows in inversion direction through the liner and exits the head of the liner.

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 14
Rehabilitation with open liner end, with LinerEndCap Open-End Method	

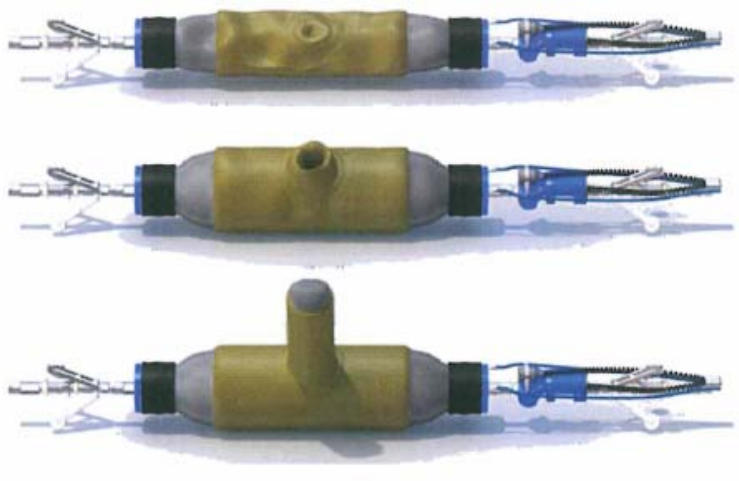
DrainLCR-S Method

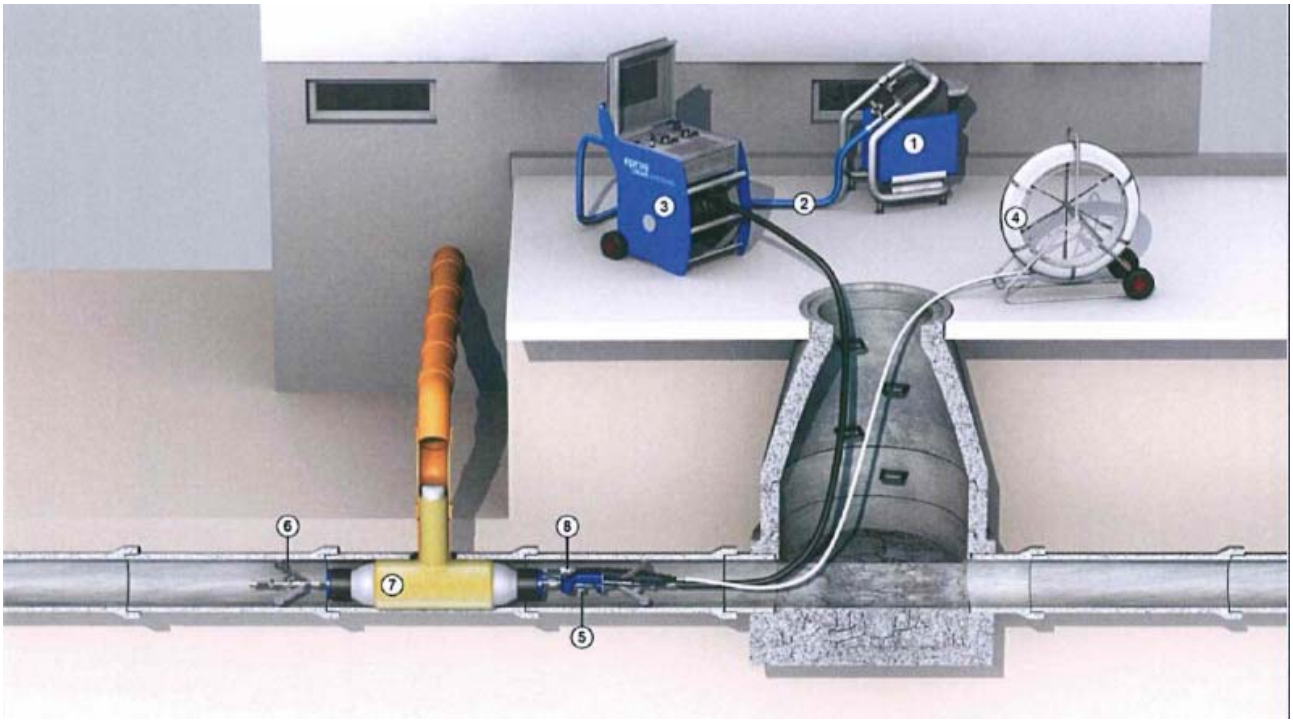
DrainLCR-S system

A. Deflated packer prior to introduction into the pipe

B. Slightly inflated packer after positioning

C. Fully inflated DrainLCR-S hat profile or DrainLCR-S liner





1. Compressor, min. 300 L/min / 8 bar
2. Compressed-air hose, 10 m
3. DrainLCR control unit
4. DrainLCR push rod
5. DrainLCR-S rotary actuator
6. DrainLCR-S wheel set
7. DrainLCR-S packer
8. DrainLCR-S camera

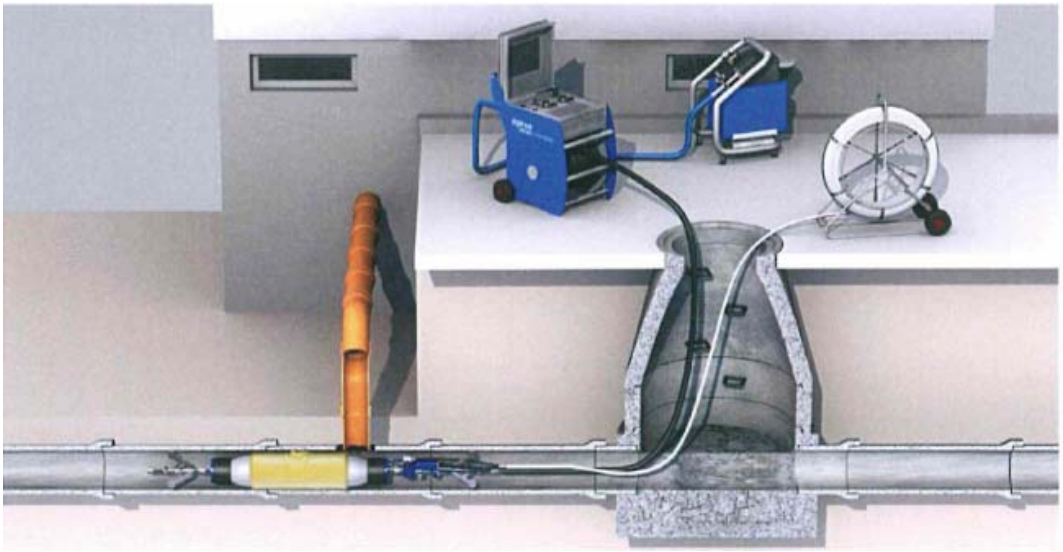
"DrainLCR method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 15
DrainLCR-S Method LCR-S hat profile & LCR-S liner	

DrainLCR-S Method
Installation Process

1. Position the DrainLCR-S packer:

Push or pull the DrainLCR-S packer way down behind the lateral. Turn the DrainLCR-S packer basket with the help of the camera until the basket is properly aligned with the lateral.

2. Lift the epros®DrainLCR packer basket:



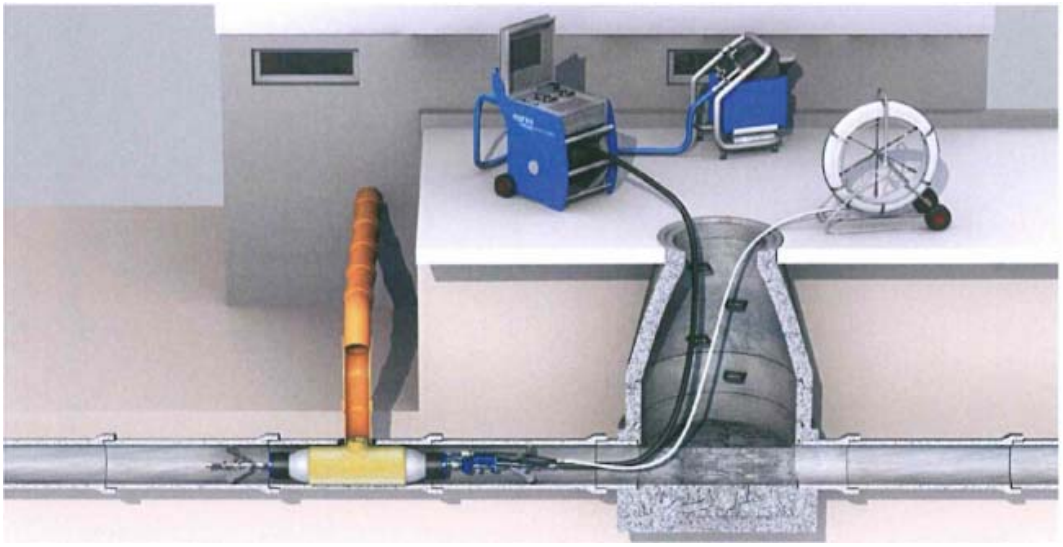
Turn the “Air/Vacuum” lever of the DrainLCR control box briefly into the “air” position. Then lift the DrainLCR packer basket by turning the “pathfinder” lever to “up”. The DrainLCR-S packer basket will then be extended against the pipe wall.

“DrainLCR-S method” with “EPROPOX HC60” resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 16
DrainLCR-S Method Installation steps Page 1 of 3	

DrainLCR-S Method
Installation Process

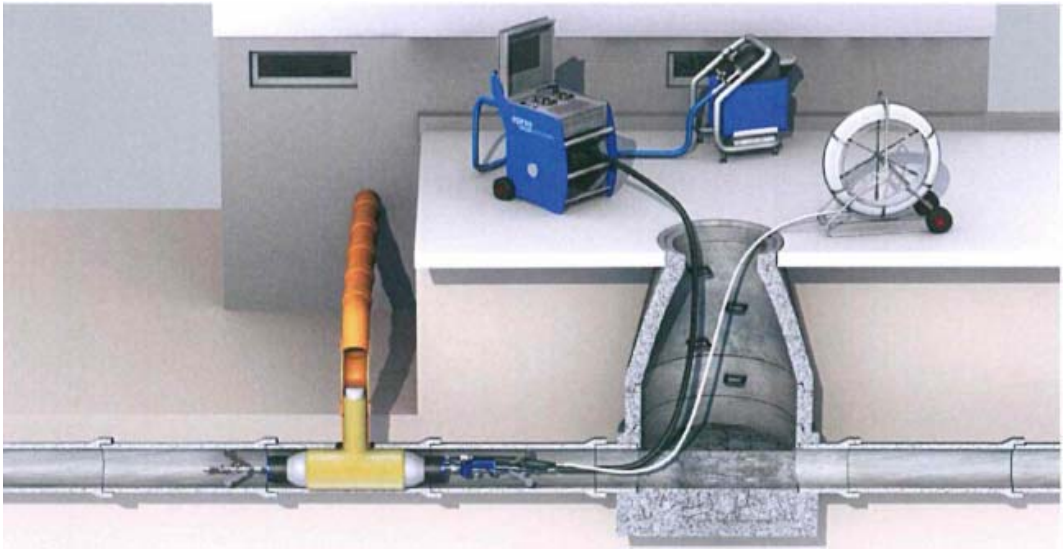
Turn the "pathfinder" (counterclockwise) into the "up" position. The DrainLCR-S packer basket will then be extended against the pipe wall.

3. Final positioning:



Draw the DrainLCR packer way back until the DrainLCR packer basket is engaged and locked with the lateral.

4. Invert the hat profile or LCR liner into the lateral connection line:



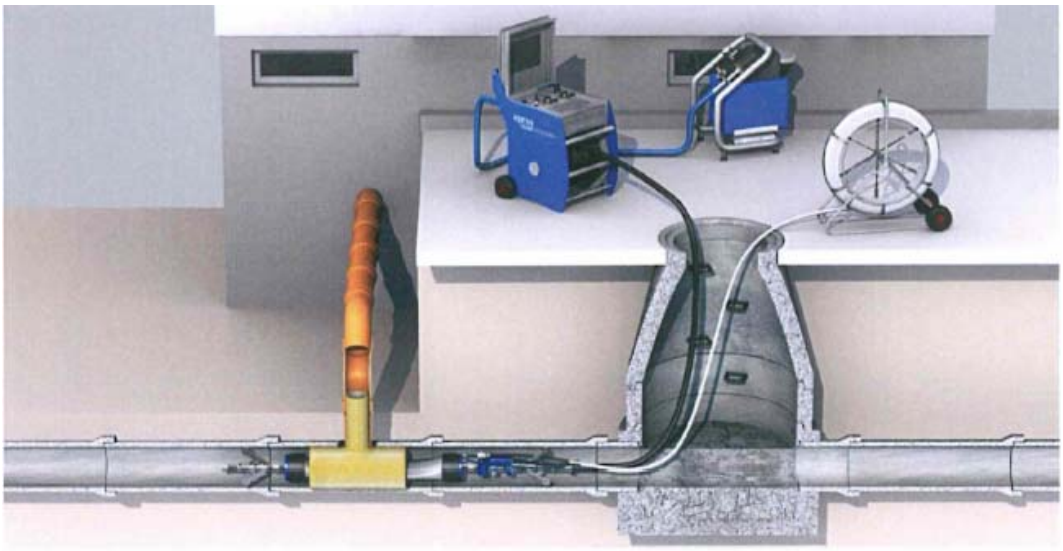
Turn the “Air/Vacuum” lever of the LCR control box back to “Air”. The inflation pressure *[sentence incomplete, the translator]*

“DrainLCR-S method” with “EPROPOX HC60” resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 17
DrainLCR-S Method Installation steps Page 2 of 3	

epros®DrainLCR Method
Installation Process

In a first step, the DrainLCR-S packer body in the main line will be filled with compressed air; the inversion process will start after complete inflation of the packer. A whistling sound will signal the end of the inversion process. The sound signal indicates that the DrainLCR-S hat profile or DrainLCR-S liner has been completely inverted into the lateral connection pipe. Turn the “pathfinder” for the DrainLCR-S packer basket to "down". The DrainLCR basket will be lowered and the sound will stop. Then set the lever to "zero". The inflation pressure must be maintained until the end of the curing process. If you wish to use the epros®DrainLCR control box for further installations, connect an air tank and maintain the inflation pressure at 0.7 bar as mentioned before.

5. Remove the epros®DrainLCR packer from the pipe:

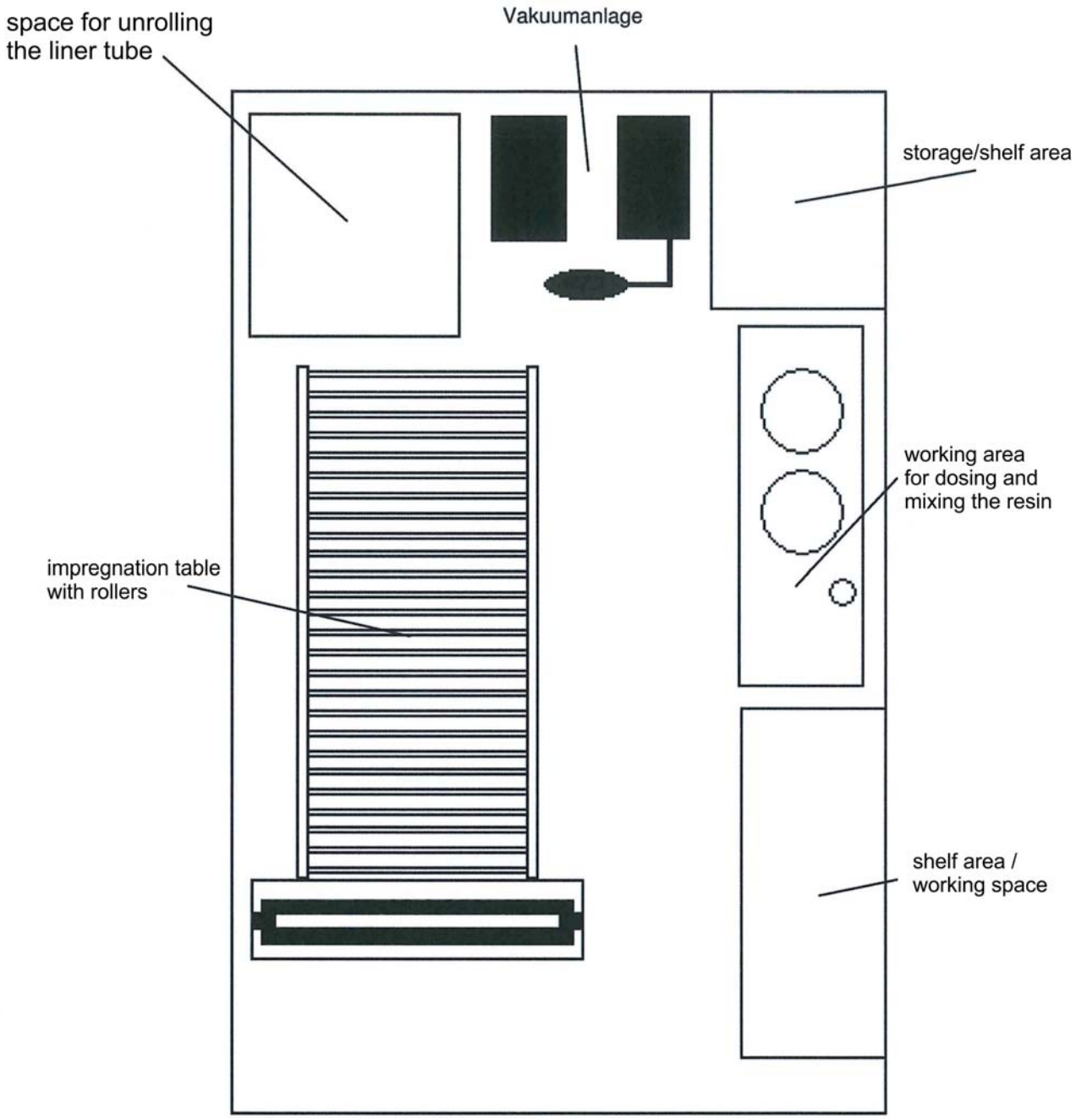


Once the curing process is complete, turn the “pathfinder” lever to “down”. Turn the "Air/Vacuum" lever to "Vacuum". After complete deflation the DrainLCR-S packer can be removed from the pipe.

The packer must be cleaned and examined for damages after use.

“DrainLCR-S method” with “EPROPOX HC60” resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 18
DrainLCR-S Method Installation steps Page 3 of 3	

Trailer configuration



"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 19
DrainLiner Method Trailer configuration	

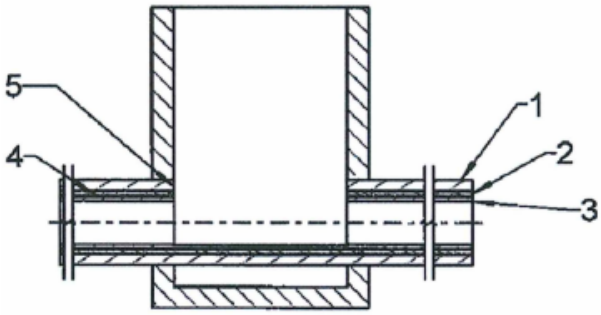
Pipe-to-Manhole Interface

Option 1

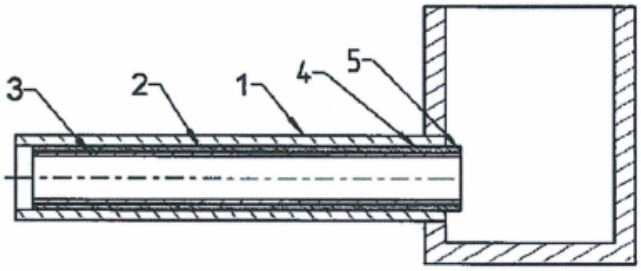
1 Host pipe
2 PE preliner
3 Impregnated polyester needle felt tube
4 Swelling tape
5 Grout seal

1 Host pipe
2 PE preliner
3 Impregnated polyester needle felt tube
4 LinerEndSeal

Intermediate manhole



Final (exit) manhole



"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 20
DrainLiner Method Pipe-to-manhole interface	

Calculation of EPROPOX HC60 usage amounts

Sprache / language / langage:	English

Calculation of usage amounts

for epros®EPROPOX epoxy resins

Liner type	DrainFlexLiner
Resin system	HC60
Units	metric

Diameter	400	mm
Wall thickness	6	mm
Length	12.5	m
Roller nip	14	mm

Resin mixture in total	98.96	Litres
	108.83	Kg

Volume	**Component A (resin)**	**70.54**	**Litres**
	Component B (hardener)	**28.42**	**Litres**

Weight	**Component A (resin)**	**81.82**	**Kg**
	Component B (hardener)	**27.00**	**Kg**

IMPORTANT
Please refer to the data sheet of both the liner and the resin system actually used

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 21
DrainLiner Method Calculation of resin usage amounts	

Inversion & Curing Pressures for epros®DrainLiner PVC / PP

Diameter		Wall thickness		*min.* inversion pressure		*max.* inversion pressure		*min.* curing pressure at 10 °C		*min.* curing pressure at 80 °C		*max.* curing pressure		Resin amount	
mm	inch	mm	inch	bar	psi	bar	psi	bar	psi	bar	psi	bar	psi	Litre/m	Gallon (US) / feet
100	4	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.04	0.08
100	4	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	1.56	0.13
125	5	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.30	0.10
125	5	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	1.95	0.16
150	6	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.56	0.13
150	6	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	2.34	0.19
150	6	6	0.24	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	3.12	0.25
200	8	3	0.12	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	2.08	0.17
200	8	4.5	0.18	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	3.12	0.25
200	8	6	0.24	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	4.15	0.33
225	9	3	0.12	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	2.34	0.19
225	9	4.5	0.18	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	3.50	0.28
225	9	6	0.24	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	4.67	0.38
250	10	4.5	0.18	0.32	4.6	0.96	13.9	0.35	5.0	0.23	3.3	0.38	5.6	3.9	0.31
250	10	6	0.24	0.40	5.8	1.36	19.7	0.49	7.1	0.33	4.7	0.54	7.9	5.2	0.42
250	10	9	0.35	0.56	8.1	2.00	29.0	0.72	10.4	0.48	7.0	0.80	11.6	7.8	0.63
300	12	6	0.24	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	6.3	0.51
300	12	9	0.35	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	9.4	0.76
300	12	12	0.47	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	12.5	1.01
350	14	6	0.24	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	7.3	0.59
350	14	9	0.35	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	10.9	0.88
350	14	12	0.47	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	14.6	1.18
375	15	6	0.24	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	7.8	0.63
375	15	9	0.35	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	11.7	0.94
375	15	12	0.47	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	15.6	1.26
400	16	6	0.24	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	8.3	0.67
400	16	9	0.35	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	12.5	1.01
400	16	12	0.47	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	16.6	1.34

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 22
DrainLiner Method Installation pressures for DrainLiner PVC / PP	

Inversion & Curing Pressures for epros®DrainFlexLiner and epros®DrainSteamLiner / PP

Diameter		Wall thickness		*min.* inversion pressure		*max.* inversion pressure		*min.* curing pressure at 10 °C		*min.* curing pressure at 80 °C		*max.* curing pressure		Resin amount	
mm	inch	mm	inch	bar	psi	bar	psi	bar	psi	bar	psi	bar	psi	Litre/m	Gallon (US) / feet
100	4	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.04	0.08
100	4	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	1.56	0.13
125	5	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.30	0.10
125	5	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	1.95	0.16
150	6	3	0.12	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	1.56	0.13
150	6	4.5	0.18	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	2.34	0.19
150	6	6	0.24	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	3.12	0.25
200	8	3	0.12	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	2.08	0.17
200	8	4.5	0.18	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	3.12	0.25
200	8	6	0.24	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	4.15	0.33
225	9	3	0.12	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	2.34	0.19
225	9	4.5	0.18	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	3.50	0.28
225	9	6	0.24	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	4.67	0.38
250	10	4.5	0.18	0.32	4.6	0.96	13.9	0.35	5.0	0.23	3.3	0.38	5.6	3.9	0.31
250	10	6	0.24	0.40	5.8	1.36	19.7	0.49	7.1	0.33	4.7	0.54	7.9	5.2	0.42
250	10	9	0.35	0.56	8.1	2.00	29.0	0.72	10.4	0.48	7.0	0.80	11.6	7.8	0.63
300	12	6	0.24	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	6.3	0.51
300	12	9	0.35	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	9.4	0.76
300	12	12	0.47	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	12.5	1.01
350	14	6	0.24	0.32	4.6	1.12	16.2	0.40	5.8	0.27	3.9	0.45	6.5	7.3	0.59
350	14	9	0.35	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	10.9	0.88
350	14	12	0.47	0.64	9.3	2.24	32.5	0.81	11.7	0.54	7.8	0.90	13.0	14.6	1.18
375	15	6	0.24	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	7.8	0.63
375	15	9	0.35	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	11.7	0.94
375	15	12	0.47	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	15.6	1.26
400	16	6	0.24	0.24	3.5	0.88	12.8	0.32	4.6	0.21	3.1	0.35	5.1	8.3	0.67
400	16	9	0.35	0.40	5.8	1.28	18.6	0.46	6.7	0.31	4.5	0.51	7.4	12.5	1.01
400	16	12	0.47	0.48	7.0	1.68	24.4	0.60	8.8	0.40	5.8	0.67	9.7	16.6	1.34

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 23
DrainLiner Method Installation pressures for DrainFlexLiner and DrainSteamLiner / PP	

Guidance for Use: DrainPlusLiner with 9% undersize

DrainPlusLiner/ pipe dimension	Unit	DN 50 in pipe DN 50	DN 50 in pipe DN 70	DN 70 in pipe DN 70	DN 70 in pipe DN100	DN100 in pipe DN100	DN100 in pipe DN125	DN100 in pipe DN150	DN125 in pipe DN125	DN125 in pipe DN150	DN150 in pipe DN150	DN150 in pipe DN200	DN200 in pipe DN200	DN200 in pipe DN225	DN200 in pipe DN250	DN225 in pipe DN225	DN225 in pipe DN250
Undersize	%	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Extra length per metre for open-end process with calibration hose in second step	cm per m	-6	13	4	15	2	10	20	-5	9	0	15	-1	8	11	0	2
Cut length per lining metre	m	0.94	1.13	1.04	1.15	1.02	1.10	1.20	0.95	1.09	1.0	1.15	0.99	1.08	1.11	1.0	1.02
Contact pressure in conjunction with lubricated calibration hose – in straight pipe	bar	0.7	0.9	0.5	1.2	0.3	0.5	1.0	0.4	0.55	0.1	0.55	0.2	0.35	0.4	0.2	0.3
	psi	10.2	19.2	7.3	17.4	4.4	7.3	14.5	5.8	8.0	1.5	8.0	2.9	5.1	5.8	2.9	4.4
Burst pressure	bar	1.2	1.2	1.3	1.3	1.3	1.2	1.3	0.9	0.9	0.8	0.8	0.8	0.8	0.8	1.2	1.2
	psi	17.4	17.4	18.9	18.9	18.9	17.4	18.9	13.1	13.1	11.6	11.6	11.6	11.6	11.6	17.4	17.4

Important comments:	• Values apply to applications using the epros®EPROPOX HC60 resin system. • The calibration hose must always be dimensioned to the largest pipe diameter. • Extra length: a value of 15 cm/m means e.g. that a length of 15 cm must be added for each metre of pipe of the relevant DN size. • All data were determined at an ambient temperature of 20°C. They are lab-scale values, which may differ under in-situ conditions. Please note that the values will change when heat is added.
Recommended use:	• For hot water cures and/or in case of diameter changes, always use the orange-coloured epros calibration hose. • Using the epros®DrainPlusLiner in connection with silicate resin may cause bubbles in the coating if the resin system isn't mixed properly.
Legal mention:	• The statements and values contained in this information sheet are made to the best of our knowledge on the basis of our experience, but they are not binding. • They need to be adjusted to the particular purposes, applications, structures and prevailing local conditions. Subject to the foregoing, we assume liability for the correctness of the statements within the scope of our standard terms & conditions of sale & delivery. • Recommendations deviating from what is indicated in our information and work sheets, whether or not made by members of our staff, shall not be binding unless or until they are confirmed in writing. The generally accepted rules of good engineering practice shall always be observed.

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400

DrainLiner Method
Guidance for use of DrainPlusLiner with 9% undersize

Appendix 24

Deutsches Institut für Bautechnik DIBt

Guidance for Use: DrainPlusLiner with 18% undersize

DrainPlusLiner/ pipe dimension	Unit	DN 50 in pipe DN 50	DN 50 in pipe DN 70	DN 70 in pipe DN 70	DN 70 in pipe DN100	DN100 in pipe DN100	DN100 in pipe DN125	DN125 in pipe DN125	DN125 in pipe DN150	DN150 in pipe DN150	DN150 in pipe DN200	DN200 in pipe DN200	DN200 in pipe DN225	DN200 in pipe DN250	DN225 in pipe DN225	DN225 in pipe DN225
Undersize	%	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Extra length per metre for open-end process with subsequent calibration hose	cm per m	-5	15	3	Not possible – use liner with 9 % undersize.	5.5	12	0	12	5	12	2	14	16	7	8
Cut length per lining metre	m	0.95	1.15	1.03		1.055	1.12	1.0	1.12	1.05	1.12	1.02	1.14	1.16	1.07	1.08
Contact pressure in conjunction with the lubricated calibration hose – in straight pipe	bar	1.1	1.2	0.8		0.3	0.6	0.3	0.5	0.3	0.6	0.3	0.4	0.5	0.2	0.4
	psi	16.0	17.4	11.6		4.4	8.7	4.4	7.3	4.4	8.7	4.4	5.8	7.3	2.9	6.8
Burst pressure	bar	1.3	1.3	1.3		1.4	1.4	1.3	1.3	1.0	1.0	0.7	0.7	0.7	1.3	1.3
	psi	18.9	18.9	18.9		20.3	20.3	18.9	18.9	14.5	14.5	10.2	10.2	10.2	18.9	18.9

Important comments:

- Values apply to applications using the epros® EPROPOX HC60 resin system.
- The calibration hose must always be dimensioned to the largest pipe diameter.
- Extra length: a value of 15 cm/m means e.g. that a length of 15 cm must be added for each metre of pipe of the relevant DN size.
- All data were determined at an ambient temperature of 20°C. They are lab-scale values, which may differ under in-situ conditions. Please note that the values will change when heat is added.

Recommended use:

- For hot water cures and/or in case of diameter changes, always use the orange-coloured epros calibration hose.
- Using the epros® DrainPlusLiner in connection with silicate resin may cause bubbles in the coating if the resin system isn't mixed properly.

Legal mention:

- The statements and values contained in this information sheet are made to the best of our knowledge on the basis of our experience, but they are not binding.
- They need to be adjusted to the particular purposes, applications, structures and prevailing local conditions. Subject to the foregoing, we assume liability for the correctness of the statements within the scope of our standard terms & conditions of sale & delivery.
- Recommendations deviating from what is indicated in our information and work sheets, whether or not made by members of our staff, shall not be binding unless or until they are confirmed in writing. The generally accepted rules of good engineering practice shall always be observed.

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400

DrainLiner Method
Guidance for use of DrainPlusLiner with 18% undersize

Appendix 25

Guidance for Use: DrainPlusLiner 1.0/2.0 with 10% undersize

epros®DrainPlusLiner 1.0 DN in mm – installed in host pipe DN in mm

Final wall thicknesses		≥ 3 mm on DN basis, in expansion: ≥ 2.5 mm																			
Resin amount calculated for		3.5 mm																			
Roller (nip) distance		9 mm																			
Liner size (mm)		70		100			125			150			200			225			250		
Pipe diameter (mm)		70	100	100	125	150	125	150	200	150	200	250	200	225	250	225	250	300	250	300	350
Extra length per metre	cm / m	-2	1	-2	1	2	-2	1	2	-2	1	2	-2	1	2	-2	1	2	-2	1	2
Cut length per lining metre	m	0.98	1.01	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02
Inversion pressure in straight pipe run	bar	0.41	0.49	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.2	0.16	0.24	0.2	0.16	0.2	0.16	0.2	0.2	0.16	0.2
Curing pressure	bar	0.33	0.49	0.24	0.28	0.33	0.24	0.28	0.24	0.16	0.24	0.2	0.2	0.24	0.28	0.16	0.2	0.16	0.2	0.16	0.2
Burst pressure	bar	1.14	1.14	0.81	0.81	0.81	0.73	0.73	0.73	0.65	0.65	0.65	0.57	0.57	0.57	0.49	0.49	0.49	0.41	0.41	0.41

epros®DrainPlusLiner 2.0 DN in mm – installed in host pipe DN in mm

Final wall thicknesses		≥ 4 mm on DN basis, in expansion: ≥ 3 mm																			
Resin amount calculated for		4.5 mm																			
Roller (nip) distance		11 mm																			
Liner size (mm)		70		100			125			150			200			225			250		
Pipe diameter (mm)		70	100	100	125	150	125	150	200	150	200	250	200	225	250	225	250	300	250	300	350
Extra length per metre	cm / m	-2	1	-2	1	2	-2	1	2	-2	1	2	-2	1	2	-2	1	2	-2	1	2
Cut length per lining metre	m	0.98	1.01	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02	0.98	1.01	1.02
Inversion pressure in straight pipe run	bar	0.5	0.6	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.25	0.2	0.3	0.25	0.2	0.25	0.2	0.2	0.25	0.2	0.2
Curing pressure	bar	0.4	0.6	0.3	0.35	0.4	0.3	0.35	0.4	0.2	0.3	0.4	0.25	0.3	0.35	0.2	0.25	0.25	0.2	0.25	0.25
Burst pressure	bar	1.4	1.4	1	1	1	0.9	0.9	1	0.8	0.8	1	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 26
DrainLiner Method Guidance for use of silicone-coated DrainPlusLiner 1.0/2.0 with **10%** undersize	

Site Visit – on-site inspection of buried pipelines

DrainLiner method – rehabilitation of underground pipes
Site visit for sectional repair / relining of sewers

Single report for each repair ☐ foul water ☐ TV pre-inspection Date of survey:

Job site Project No.: storm water ☐ available ☐ Name:

Street address combined sewer ☐ not available ☐ Name:

From manhole (1) no.	To manhole (2) no.	MH depth (manhole 1)	MH depth (manhole 2)	DN (mm) checked?	DN acc. to site plan	Length in metre	Profile shape	Egg-shaped: pipe circumference	Remarks: MH centre to MH centre distance

Distances from rig or inversion drum — Remarks: — Sketch if necessary

Standpost hydrant		m
Undergr. hydrant		m
Hose racks	yes	☐
	no	☐
Road width		m
Truck accessibility	yes	☐
	no	☐
	distance (m)	
Traffic load	private site	☐
	side road	☐
	main road	☐
Traffic control required	yes	☐
	no	☐
Service flow management	yes	☐
	no	☐
Flow management by	plugging	☐
	pumping	☐
Containment of lateral flow	yes	☐ inspection manhole available: yes ☐ no ☐
	no	☐

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	
DrainLiner Method Site Visit Form for inspection of buried pipes	Appendix 27

Site information

Site Information	
CIPP truck:	
Operator:	
Site manager:	
Project:	
Cost Centre	
Client:	
Contact:	
Meeting point:	
Works:	
Subcontractor:	
Miscellaneous:	

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 28
DrainLiner Method Site Data Form	

Fabrication Report

epros®DrainLiner Method for the rehabilitation of damaged sewer line
Liner Fabrication Report

Project Data

CIPP truck:		Date:		Site No.:	
Project:					
Street address:		ZIP code:		Town/city:	
Client:					
Job No.:		From point:		To point:	
Pipe shape:		DN:	mm	Liner length	
				Target wall thickness	

Material / Material Consumption

Carrier material

epros®DrainFlexLiner (PP)		Batch No. / wall thickness	/	mm
epros®DrainLiner (PP)		Batch No. / wall thickness	/	mm
epros®DrainLiner (PVC)		Batch No. / wall thickness	/	mm
epros®DrainSteamLiner (PP)		Batch No. / wall thickness	/	mm
epros®DrainHybridLiner "S"		Batch No. / wall thickness	/	mm
epros®DrainHybridLiner "P"		Batch No. / wall thickness	/	mm
epros®DrainPlusLiner (PUR)		Batch No. / wall thickness	/	mm
epros®DrainPlusLiner 1.0 (SK)		Batch No. / wall thickness	/	mm
epros®DrainPlusLiner 2.0 (SK)		Batch No. / wall thickness	/	mm

Resin system name / type:

Basic Data

Resin data	Target*	Actual
Storage temperature	s. data sheet	*C
Resin : hardener mixing ratio (kg)	: (see TDS)	:
Mixing temperature		
Pot time at 25°C in minutes	HB: Tab. 11	
Usage amount of component A (kg)		
Usage amount of component B (kg)		
Total usage amount of components A + B		
Comp. A Batch no.:		
Comp. B batch no.:		

Fabrication Conditions

		Target*	Actual
Impregnation	Vacuum	0.5 bar	
	Roll nip setting	2 x "s" + 2 mm	
Temperatures	Ambient (°C)		
	Resin (°C)		
	Hardener (°C)		
	Liner after impregnation (°C)		
		Start (time)	End (time)
Time / duration	Mixing target: 3 minutes		
	Impregnation		
	Inversion		
	Filling with water		

On-site retention samples Carrier material / site description

Carrier material / site description

Remarks

Date Signature

* Target values must be taken from the Method Statement or Technical Data Sheets according to the resin system used.

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400

DrainLiner Method
Liner Fabrication Report Form

Appendix 29

Liner Installation Report

CIPP truck: _____ Date: _____ Site No.: _____

Project _____

Street address _____

Client _____

Job No. _____ from point _____ to point _____

Pipe shape: _____ Final wall thickness: _____ mm

DN _____ mm MH-to-MH length: _____ m

Inversion method:

Water column		*Inversion drum*	
Rig height + manhole:	_____ metres	Inversion pressure:	_____ bar
Water pressure:	_____ bar	Curing pressure:	_____ bar

Downstream inversion: ☐ closed end: ☐

Upstream inversion: ☐ open end: ☐

Groundwater encountered?	yes ☐	☐ no
Preliner inverted?	yes ☐	☐ no
Calibration hose used?	yes ☐	☐ no

Curing method:

Hot water:: ☐ Steam: ☐ Ambient: ☐

Amount of water required for hot cure: _____ m²

Curing from _____(time) to _____(time) Checked (name):_____

Cooling from _____(time) to _____(time) Checked (name):_____

Sampling position:

Sample taken from manhole no. _____ Wall segment: ☐

Supporting pipe: ☐

Length of head section: _____ m (with closed end)

Signature: Responsible person (foreman): _____ Date: _____

"DrainLiner method" with "EPROPOX HC60" resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400	Appendix 30
DrainLiner Method Liner Installation Report Form	

Curing Report

DrainLiner Method for rehabilitation of buried pipes
Liner Cure Report

Date: _____

Project: _____

Client: _____

Pipe run: _____ **Operative:** _____

Plant: _____ **1st measurement at :** _____ (time)

Measuring points schedule

a	—	Air temperature	°C
b1	—	Hot water flow temperature	°C
b2	—	Steam/air mix temperature	°C
c	—	Curing pressure	bar

		Meas.point 1	Meas.point 1	Meas.point 1	Time	°C	Remark
1	—						
2	—						
3	—						
4	—						
5	—						
6	—						
7	—						
8	—						
9	—						
10	—						
11	—						
12	—						
13	—						
14	—						
15	—						
16	—						
17	—						
18	—						
19	—						
20	—						

Leakage/Tightness Test

Leakage Test Report

1. Project Data:			
Project:			
Address:		ZIP/town:	
Client:			
Address:		ZIP/town:	
Installer:			
Address:			
Type of liner:	○ CIPP liner ○ Short liner	Product description:	
Leakage test:			
Address:		ZIP/town:	
2. Drain/Sewer Line Data			
Sewage type:	○ Foul water ○ Stormwater ○ Combined sewer		
Pipe geometry:	○ Circular ○ Egg-shaped		
Liner material:		DN size/bore:	Lining date:
Pipe section #			
MH-to-MH length:			
from manhole		to manhole:	

3. Air tightness test:					
Test method:	○ LA		○ LB	○ LC	○ LD
Test pressure p_0:	_____ mbar		Stabilisation time:	_____ min	
adm.press.loss Δp	_____ mbar		Test duration:	_____ min	
Start pressure:	_____ mbar				
Final pressure:	_____ mbar		Pressure drop:	_____ mbar	

4. Water tightness test:		
○ Pipes only	○ Manholes and inspection holes	○ Pipe with manhole
Test duration:	30	min
Water head above pipe crown at start of test (water gauge [WG]))		kPa (= mWG· 10)
Water added:		L
Water added / manhole-to-manhole length:		L/m²
Admissible make-up water per m² of wetted area acc. to DIN EN 1610:	0.15	L/m²
Calculated admissible total make-up water as referred to the test section		L
Actual amount of make-up water		L

5. Result			
Test passed:	○ yes ○ no		
Comments:			
Place / date:		Signature	

“DrainLiner method” with “EPROPOX HC60” resin system for the rehabilitation of buried damaged sewer lines in the sizes DN 100 to DN 400

DrainLiner Method
Leakage Test Report

Appendix 32

Sample Delivery Note

SAMPLE DELIVERY NOTE FOR TESTING OF LINER MATERIAL

☐ *INITIAL TEST* ☐ *REPEATED TEST* *for Test Report No.* ____

1. Sampling data:

Sample taken by:		Test institute:	
Date / time:		Address:	

2. Sample identification:

Project:			Material ID:			
Project owner / client:			Sample description:			
Cost centre:			Sewer line description:			
Installer firm:			Nominal diameter:			
Liner manufacturer:			Date installed:			
Carrier material:			Host pipe condition:	O I	O II	O III
Resin material:			Sampling location:	O MH-MH line	O final MH	O interm. MH
Pipe geometry:	O circular	O egg shape	Sampling position:	O crown	O springline	O invert

3. Required initial properties according to structural design calculations:

Flexural E-modulus$_{DIN}$ E_f [N/mm²]:		Circumferential E-modulus E_U [N/mm²]:	
Flexural stress$_{at\ first\ break}$ σ_{fB} [N/mm²]:		Initial ring stiffness S_0 [N/m²]:	
Wall thickness **d** [mm]:		Maximum creep K_{N24} [%]:	
Reduction factor A_1 :		Density δ [g/cm³]:	

4. Test results:

Flexural modulus, bending stress acc. to DIN EN ISO 178

Date tested	E_f [N/mm²]	σ_{fB} [N/mm²]	h [mm]
	Load type	O axial	O radial

24 h creep after DIN EN ISO 899-2

Date tested	K_N [%]

Circumf. E-modulus, initial ring stiffness acc. to DIN EN 1228

Date tested	E_U [N/mm²]	S_0 [N/m²]	h [mm]

24 h creep after DIN EN 761

Date tested	K_N [%]

Water tightness acco. to DIN EN 1610

Date tested	Load period	Test pressure [bar]	Test result	
	30 minutes		O passed (tight)	O failed (leaking)

Calcination method acc. to DIN EN ISO 1172

Date tested	Resin [%]	Total residues [%]	Glass content [%]	Additive [%]

Spectral analysis after ASTM D 5576 (FT-IR)

Date tested	EP resin	UP resin	VE resin	Other resin

Density acc. to DIN EN ISO 1181-1 or -2

Date tested	δ [g/cm³]

Thermal analysis acc. to DIN EN ISO 11357-1 / DSC analysis DIN 53765 Method A

Date tested	Glass transition temperature [°C]			Enthalpy [J/g]	
	T_{G1}		ΔT_G	O exothermic	O endothermic
	T_{G2}				

Residual styrene content acc. to DIN 53394-2 (GC)

Date tested	Weighed-in quantity [mg]	Residual styrene [mg/kg]	Residual styrene [%]	Weight-in quantity referred to	
				O Total quantity	O Pure resin

5. Evaluation of results:

Requirement	met	not met	Requirement	met	not met
Flexural-E-modulus E_f	O	O	Circumfer. E-modulus E_U	O	O
Flexural stress σ_{fB}	O	O	Initial ring stiffness S_0	O	O
Wall thickness **d**	O	O	24 h creep K_N	O	O
Water tightness	O	O	Density δ	O	O

6. Remarks:

7. Signature of tester / laboratory: