German Institute for Civil Engineering

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Approval body for construction products and types of construction

Construction engineering test office

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General building approval/General type approval

Translation of the original German version not checked by the German Institute for Civil Engineering

Number:
Z-42.3-566

Period of validity
from: **26 April 2019**
until: **26 April 2024**

Applicant:
BRAWOLINER
KARL OTTO BRAUN GmbH & Co. KG
Blechhammerweg 13-17
67659 Kaiserslautern, Germany

Subject of this decision:
Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing.

The aforementioned object of regulation is hereby awarded general building accreditation/approval.
This decision comprises 21 pages and 15 appendices.

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I GENERAL PROVISIONS

1 With this decision, the usability or applicability of the object of the regulation according to the state building regulations is certified.

2 This decision does not replace the permits, approvals and certificates required by law for the execution of construction projects.

3 This decision is issued without prejudice to the rights of third parties, in particular private property rights.

4 Irrespective of further regulations in the "Special Provisions", copies of this decision shall be made available to the user of the object of the regulation. In addition, the user of the object of the regulation needs to be informed that this decision must be available at the place of use or application. Copies shall also be made available to the authorities concerned on request.

5 This decision may only be reproduced in its entirety. Publication in extracts requires the consent of the German Institute for Building Technology. Texts and drawings of promotional literature may not contradict this decision, translations must contain the note "Translation of the original German version not checked by the German Institute for Building Technology".

6 This decision is revocable. The provisions may be supplemented and amended subsequently, in particular where new technical knowledge so requires.

7 This decision refers to the information and documents provided by the applicant. Any change to these principles is not covered by this decision and must be disclosed to the German Institute for Building Technology without delay.

8 The general type approval covered by this decision is also considered to be the general building approval for the type.

II SPECIAL PROVISIONS

1 Object of approval and scope of application

This general building approval applies to the manufacture and use of hose liners with the designation "BRAWOLINER®" (Appendix 1) using styrene-free vinyl ester resin with the designation "BRAWO® LR" and a polyester synthetic fibre hose with the designation "BRAWOLINER® 3D".
The hose liners are designed for the rehabilitation or refurbishment of damaged, underground waste water pipes with circular cross-sections in the nominal diameters DN 100 to DN 225 for sewage in accordance with DIN 1986-3[1].
The "BRAWOLINER®" can be used for the rehabilitation or refurbishment of waste water pipes with circular cross-sections made of concrete, reinforced concrete, stoneware, asbestos-free fibre cement, GRP, PVC-U, PE-HD and cast iron, provided that the cross-section of the waste water pipe to be refurbished meets the process-related requirements and the static requirements.
Damaged waste water pipes are rehabilitated by introducing the above-mentioned resin-impregnated polyester synthetic fibre hose and subsequently curing it with LED or UV light.
In groundwater saturated zones (groundwater infiltration), a PE protective hose (preliner) must always be pulled in before the hose liner is inverted.
Side inlets can be restored either in open construction or by means of repair or rehabilitation procedures, for which general building approvals (e.g. "BRAWOLINER connection collar" with the general building approval no. Z-42.3-362) are valid.

2 Provisions applicable to construction products

2.1 Properties and composition

Where applicable, the hose liners described in Section 1 meet the requirements of DIN EN ISO 11296-4[2] and have the specific properties and compositions listed below.

2.1.1 Materials of the components in the "M" state

2.1.1.1 Materials for inversion hoses

The material of the PE preliner, the polyester synthetic fibre hose, its thermoplastic polyurethane film coating TPU (Appendix 1), the translucent polyvinyl chloride PVC calibration hose (support hose) and the VE resin materials correspond to the formulation specifications filed at the German Institute for Construction Engineering.
The resin system must correspond to the IR spectra filed at the German Institute for Construction Engineering. The IR spectra must also be filed with the third-party monitoring body. The polyethylene (PE) used in the preliner meets the requirements of DIN EN ISO 1872-1[3].
The translucent calibration hose (support hose) consists of a polyester fabric which is coated with PVC.

1) According to DIN EN 29073-1[4], the polyester synthetic fibre hoses have the following properties:
   - Surface weight: approx. 2,900 g/m² (double layer) with approx. 6.0 mm wall thickness
   - Average fibre length: = 25 µm
   - Tear strength ≥ 8 N/mm²
   - Lateral elongation: ≥ 50 %
2) The thermoplastic TPU film coating on the polyester synthetic fibre hose has the

[1] DIN 1986-3 Drainage systems for buildings and land - Part 3: Rules for operation and maintenance; edition:2004-11
[2] DIN EN ISO 11296-4 Plastic pipe systems for the rehabilitation of underground pressureless sewer systems (open channel pipes) - Part 4: On-site curing hose lining (ISO 11296-4:2009, corrected version 2010-06-01); German version EN ISO 11296-4:2011; Edition:2011-07
[3] DIN EN ISO 1872-1 Plastics - Polyethylene (PE) moulding compounds - Part 1: Designation system and basis for specifications (ISO 1872-1:1993); German version EN ISO 1872-1: 1999; edition:1999-10
[4] DIN EN 29073-1 Textiles; test methods for nonwovens - Part 1: Determination of mass per unit area (ISO 9073-1:1989); German version EN 29073-1:1992; Edition: 1992-08

following characteristic properties:

- Film thickness: of the film for DN 100 to <DN 150: 110 µm ±10%
  of the film for >DN 150 to DN 225: 150 µm + 10 %
- Elongation at break in longitudinal direction: ≥ 300 %
- Elongation at break in lateral direction: ≥ 300 %

3) The VE resin system "BRAWO® LR" has the following properties before processing:
   - Density according to DIN 51757[5] method 2 at +23 °C: 1.13 g/cm³ ± 10 %
   - Viscosity according to DIN EN ISO 3219[6] at +23 °C
   - Shear rate 20.04 s^{-1}: 2,811 mPa x s ± 10 %
   - Viscosity according to DIN EN ISO 3219[6] at +25 °C
   - Shear rate 20.04 s^{-1}: 2,335 mPa x s ± 10 %
   - pH value according to DIN 38404-5[7] at +23 °C: 5 to 6
   - Reactivity according to DIN EN ISO 11357-1[8]: 2.1 minutes
4) The cured VE resin system "BRAWO® LR" has the following properties:
   - Density at +23 °C according to DIN EN ISO 1183-1[9]: 1.22 g/cm³ ± 10 %
   - Flexural elastic modulus according to DIN EN ISO 178[10]: ≈ 2,400 N/mm²
   - Flexural stress σ_{fB} according to DIN EN ISO 178[10]: ≈ 75 N/mm2
   - Tensile strength according to DIN EN ISO 527-2[11]: ≈ 35 N/mm2
   - Elongation at break according to DIN EN ISO 527-2[11]: ≈ 2.2 %
   - Compressive yield stress according to DIN EN ISO 604[12]: ≥ 138 N/mm²
   - Compressive elastic modulus according to DIN EN ISO 604[12]: ≥ 1,541 N/mm²
   - Heat deflection temperature under load according to DIN EN ISO 75-2[13]: ≈ 58 °C

2.1.1.2 Material of the swelling tape (auxiliary material)

Only extruded profiles consisting of a chloroprene (CR/SBR) rubber and water-absorbing resin may be used for the swelling tape (auxiliary material) in the area of the shaft connection of the hose liner. The swelling tapes must show a volume increase of at least 100 % after 72 hours when stored in water.

The compliance of the swelling tapes with the geometric requirements (profile shape and dimensions) as specified in Appendix 11 shall be checked visually and by random sample remeasurement as part of the receiving inspection.

2.1.2 Environmental compatibility

The construction product meets the requirements of the principles for "Assessment of the Effects of Construction Products on Soil and Groundwater" (Version: 2011; Publications by the German Institute for Construction Engineering). This statement only applies if the special provisions of this general building approval are complied with.

The reservation of permission by the competent water authority, in particular in water protection zones, remains unaffected.

5	DIN 51757	Testing of mineral oils and related substances - Determination of density; Edition:2011-01
6	DIN EN ISO 3219	Plastics - Polymers/resins in liquid, emulsified or dispersed state - Determination of viscosity by means of a rotational viscometer with defined shear rate (ISO 3219:1993); German version EN ISO 3219:1994; Edition: 1994-10
7	DIN 38404-5	German standard method for water, waste water and sludge analysis - Physical and physico-chemical parameters (Group C) - Determination of the pH value (C5); editions 984-01
8	DIN EN ISO 11357-1	Plastics - Differential dynamic thermal analysis (DSC) - Part 1: General principles (ISO 11357-1:2016); German version EN ISO 11357-1:2016; Editions 7-02
9	DIN EN ISO 1183-1	Plastics - Methods for determining the density of non-foamed plastics - Part 1: Immersion, liquid pycnometer and titration methods (ISO 1183-1:2012); German version EN ISO 1183-1:2012, Edition:2013-04
10	DIN EN ISO 178	Plastics - Determination of flexural properties (ISO 178:2010); German version EN ISO 178:2010; Editions 1-04
11	DIN EN ISO 527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion compounds (ISO 527-2:1993 including Cor.1:1994); German version EN ISO 527-2:1996; Editions 996-07
12	DIN EN ISO 604	Plastics - Determination of compressive properties (ISO 604:2002); German version EN ISO 604:2003; Edition:2003-12
13	DIN EN ISO 75-2	Plastics - Determination of heat deflection temperature under load - Part 2: Plastics and hard rubber (ISO 75-2:2013); German version EN ISO 75-2:2013; Edition:2013-08

2.2 Manufacture, packaging, transport, storage and labelling

2.2.1 Manufacture

From the polyester fibre threads supplied by the sub-supplier, seamless hoses are manufactured in the applicant's factory as single-layer knitted fabric with a minimum wall thickness of 5 mm for the nominal diameter range from DN 100 to DN 225 in accordance with the requirements in Section 2.1.1.1 (1). After production of the polyester fibre knitted fabric, the hoses are laminated with the thermoplastic polyurethane film (TPU) supplied by the sub-supplier in accordance with Section 2.1.1.1 (2).

During production, the following manufacturing parameters are checked and recorded:

- Surface weight
- Thickness
- Tear strength
- Lateral elongation
- Impermeability

In order to check the properties of the thermoplastic TPU film mentioned in Section 2.1.1.1 as well as those of the PE preliner and the translucent PVC calibration hose (support hose), the applicant shall have at least factory certificates 2.1 according to DIN EN 1020414 submitted by the sub-supplier for each delivery.

In order to check the properties of the VE resin in accordance with the formulation specifications, the applicant shall have at least factory certificates 2.2 according to DIN EN 10204[14] submitted by the sub-supplier for each delivery.

The following properties shall be checked in accordance with Section 2.1.1.1 (3) as part of the incoming goods inspection:

Properties of the resin:

- Density
- Viscosity
- Reactivity

When processing the resin, the relevant accident prevention regulations and health and safety regulations must be observed.

When impregnating polyester synthetic fibre hoses and when handling them on the construction site, the relevant accident prevention regulations and the provisions of the health and safety regulations must be observed.

The VE resin must be tested with regard to its curing behaviour. The tests shall be performed in accordance with DIN 16945[15].

The determined values shall be recorded in writing by batch. In order to check the storage stability, samples of the resin shall be taken and kept at least until the respective rehabilitation measure has been completed or the use-by date has expired.

2.2.2 Packaging, transport, storage

The polyester synthetic fibre hoses coated with thermoplastic TPU films must be packed in such a way that the hoses are not damaged.

The hoses shall be stored dry and without sunlight at temperatures between +5 °C and +25 °C until further use.

The VE resin "BRAWO® LR" supplied by the sub-supplier for resin impregnation on the respective construction site must be stored in suitable, airtight containers on the applicant's premises until further use. The temperature range from $\geq$ +5 °C to approx. +30 °C must be observed. The containers can be kept for 6 months when sealed at the factory and must be protected from direct sunlight.

During storage and transport, the relevant accident prevention regulations and the instructions in the applicant's manual must be observed.

2.2.3 Labelling

The polyester synthetic fibre hoses and the respective transport containers for the resin components shall be marked with the conformity symbol (Ü symbol) in accordance with the conformity symbol ordinances of the federal states, including the indication of the general building approval No. Z-42.3-566. The labelling may only be carried out if the requirements

[14] DIN EN 10204 Metallic products - Types of test certificates; German version EN 10204:2004; Edition:2005-01

[15] DIN 16945 Reactive resins, reactants and reactive resin compounds; test methods; Edition: 1989-03

in accordance with Section 2.3 Certificate of Conformity are fulfilled.
The manufacturer must indicate the hazard symbols and H and P phrases in accordance with the Hazardous Substances Ordinance and EU Regulation No. 1907/2006 (REACH) as well as the current version of CLP Regulation (EC) 1272/2008[16] on the containers, packaging, package insert or on the delivery note.
The packaging must be labelled in accordance with the CMR[17] rules in the versions currently in force.
In addition, the following must be specified on the transport containers used for the polyester synthetic fibre hoses for the hose liners:

- Nominal diameter
- Length
- Wall thickness
- Designations "BRAWOLINER 3D"
- Batch number

In addition, the transport containers for the VE resin must be labelled with at least the following:

- Resin designation "BRAWO® LR"
- Temperature range
- Container contents (volume or weight)

2.3 Certificate of conformity

2.3.1 General

The certificate of conformity for the hose liners (construction products) with the provisions of the general building approval covered by the decision must be made for each manufacturing plant with a declaration of conformity based on a factory production control and a certificate of conformity from a certification body recognised for this purpose as well as regular external inspection by a recognised inspection body including initial testing of the construction products in accordance with the following provisions.
For the issue of the certificate of conformity and external monitoring, including the product tests to be carried out, the manufacturer of the construction products must involve a certification body recognised for this purpose and a monitoring body recognised for this purpose.
The declaration of conformity shall be issued by the manufacturer by marking the construction products with the conformity symbol (Ü symbol) indicating the intended use.
A copy of the certificate of conformity issued by the certification body shall be made available to the German Institute for Construction Engineering by the certification body.
The German Institute for Construction Engineering must also be provided with a copy of the initial test report.

2.3.2 In-house production control

An in-house production control shall be set up and carried out in each manufacturing plant.
In-house production control means the continuous monitoring of production to be carried out by the manufacturer to ensure that the construction products that it manufactures comply with the provisions of the general building approval covered by this decision.
The in-house production control shall include at least the measures listed below:

- Description and verification of the starting material:
  a) <u>For the hose liner materials:</u>
  For each delivery of the components comprising thermoplastic TPU films, polyester fibres, PE preliners, translucent PVC calibration hoses and VE resin, the operator of the manufacturing plant must ensure that they comply with the required properties in accordance with Section 2.1.1. For this purpose, the operator of the manufacturing plant must have the relevant factory certificates 2.2 according to DIN EN 10204[14] submitted by the respective supplier. Within the scope of the incoming goods inspection, the properties specified in Section 2.1.1.1 shall also be randomly checked.

[16] 1272/2008 — Regulation (EC) No. 1272/2008 on classification, labelling and packaging of substances and mixtures

[17] CMR — European Convention on the Contract for the International Carriage of Goods by Road (*Accord européen relatif au transport international des marchandises Dangereuses par Route*)

b) For the swelling tapes (auxiliary materials):
For each delivery of the swelling tapes, the applicant shall have the properties specified in Section 2.1.1.2 confirmed to it by the sub-supplier by submitting works certificates 2.2 in accordance with DIN EN 10204[14].
Compliance with the geometric requirements (profile shape and dimensions) of the swelling tapes shall be checked visually and by random sample remeasurement as part of the incoming inspection.

- Checks and tests to be carried out during manufacture:
  The requirements under Sections 2.2.1 and 2.2.3 shall be verified.

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

- Name of the construction products or the starting materials and components,
- Type of check or test,
- Date of manufacture and testing of construction products and starting materials or components,
- Result of the checks and tests and, where applicable, 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 shall be submitted to the inspection body responsible for external monitoring. They must be submitted to the German Institute for Construction Engineering and the responsible highest building supervisory authority upon request.

If the test result is unsatisfactory, the manufacturer shall immediately take the necessary measures to remedy the defect. Construction products which do not meet the requirements shall be handled in such a way as to avoid confusion with conforming products. Once the defect has been remedied - insofar as this is technically possible and necessary to prove that the defect has been remedied - the relevant test shall be repeated without delay.

2.3.3 External monitoring

At each manufacturing plant, the in-house production control must be regularly inspected by an external monitoring body, but at least once every six months.

Within the scope of external monitoring, an initial test of the construction products shall be carried out. The in-house production control shall be carried out within the scope of external monitoring by random sample checks. The requirements of Sections 2.1.1 and 2.2.3 shall be verified in this respect. Wall thicknesses of the polyester synthetic fibre hose related to rehabilitation objects shall be measured randomly before impregnation with resin. In addition, the manufacturing requirements according to Section 2.2.1 shall be randomly checked. This also includes checking the curing behaviour, storage stability and surface weight after curing, as well as IR spectroscopy.

Sampling and testing shall be the responsibility of the recognised monitoring body. In the case of external monitoring, the factory certificates 2.1 and 2.2 based on DIN EN 10204[14] shall also be checked.

The results of the certification and external monitoring shall be kept for at least five years. They must be submitted by the certification body or the monitoring body to the German Institute for Construction Engineering and the responsible highest building supervisory authority upon request.

3 Provisions for the application of the object of approval

3.1 Planning and dimensioning

3.1.1 Planning

The details of the necessary sewer or pipe data must be checked, e.g. line layout, depth, position of side inlets, shaft depths, groundwater, pipe connections, hydraulic conditions, inspection openings, cleaning intervals. Existing video recordings must be evaluated in relation to the application. The correctness of the information shall be verified on site. The assessment of the condition of the existing waste water pipe of the property drainage system with regard to the applicability of the rehabilitation procedure shall be carried out.

The hydraulic effectiveness of the waste water pipes must not be impaired by the installation of a hose liner. Corresponding evidence is to be kept if necessary.

3.1.2 Dimensioning

3.1.2.1 Hose liner in T-state

3.1.2.1.1 Wall thickness and wall construction

After inversion and curing, the hose liners must have a three-layer wall construction consisting of the PE preliner, the polyester synthetic fibre hose and the thermoplastic TPU coating (Appendix 1) or a two-layer wall composition without the preliner.

The wall thickness of the cured hose liner shall be checked by a static calculation in accordance with worksheet DWA-A 143-2[18] (see also Section 3.1.2.1.3).

For the static calculation in accordance with Section 3.1.2.1.3, the minimum wall thicknesses specified in Table 1 shall be noted. The wall thickness of the cured hose liner shall be verified by a material sample.

If the old pipe ground system alone is no longer capable of bearing loads, such waste water pipes with hose liners of the wall thicknesses listed in Table 1 may only be rehabilitated if the static loads to be absorbed by the hose liner are verified by a static calculation in accordance with worksheet DWA-A 143-2[18].

Waste water pipes whose load bearing capacity alone (without support of the surrounding soil) is provided, i.e. no cracks are present (except for hairline cracks with crack widths below 0.15 mm or in the case of reinforced concrete pipes below 0.3 mm), may only be rehabilitated with hose liners according to Table 1 if the cured minimum wall thickness does not fall below 3 mm and a stiffness SN $\geq$ 500 N/m² is maintained. If there are one or more continuous longitudinal cracks in the old pipe, soil investigations, e.g. using dynamic probing, are necessary and a corresponding mathematical verification must be carried out. In case of infiltrations, the hose liner must be dimensioned with regard to its deformation and buckling behaviour.

The following relationships apply to the nominal stiffnesses SN and short-term ring stiffnesses SR:

The following applies to SN:

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

The following applies to SR:

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

(SN = nominal stiffness according to DIN 16869-2[19])

Table 1: "Minimum wall thicknesses of the cured hose liner with associated stiffnesses."

Outer diameter of the hose liner DN [mm]	Minimum wall thickness [mm]	Nominal stiffness SN [a] [N/m²]	Ring stiffness SR [b] [N/mm²]
100	4.0	15,673	0.12539
125	3.5	5,179	0.04143
150	3.0	1,842	0.01473
150	4.0	4,456	0.03565
200	3.5	1,224	0.00979
225	3.0	535	0.00428

[a] SN= Nominal ring stiffness according to DIN 16869-2

[b] Styrene-free VE resin: Circumferential elastic modulus = 2,600 N/mm² according to DIN EN 1228

3.1.2.1.2 Physical characteristics of the cured hose liner

After curing, the hose liners (without preliner and without thermoplastic TPU coating) must have the following properties:

- Density according to DIN EN ISO 1183-1[12]: 1.22 g/cm³ + 0.10 g/cm³
- Tensile strength according to DIN EN ISO 527-4[20]: ≈ 16 N/mm²
- Tensile elongation according to DIN EN ISO 527-4[20]: ≈ 1.5 %

[18] DWA-A 143-2 German Association for Water Management, Waste Water and Waste e. V. (DWA) - Worksheet 143: Rehabilitation of drainage systems outside buildings - Part 2: Static calculations for the rehabilitation of waste water pipes and sewers with lining and assembly method; Edition:2015-07

[19] DIN 16869-2 Glass-fibre reinforced polyester resin (UP-GF) pipes, centrifugally cast, filled - Part 2: General quality requirements, testing; Edition:1995-12

[20] DIN EN ISO 527-4 Plastics - Determination of tensile properties - Part 4: Test conditions for isotropic and anisotropic fibre-reinforced plastics (ISO 527-4:1997); German version EN ISO 527-4:1997; Edition: 1997-07

- Compressive strength according to DIN EN ISO 604[21]: ≥ 52 N/mm²
- Short-term circumferential elastic modulus according to DIN EN 1228[22]: ≥ 2,600 N/mm²
- Flexural elastic modulus according to DIN EN ISO 11296-4[2] or DIN EN ISO 178[10] radial: ≥ 2,500 N/mm²
- Flexural stress σ_{fB} according to DIN EN ISO 11296-4[2] or DIN EN ISO 178[10] radial: 32 N/mm²

3.1.2.1.3 Static calculation of the cured hose liner

A static calculation ensures the stability of the intended hose liners for each rehabilitation measure according to worksheet DWA-A143-2[18] issued by the German Association for Water Management, Waste Water and Waste e.V. (DWA) before execution.
Table 1 must be observed.
The reduction factor A for determining the long-term value after 6,000 h testing according to DIN EN 761 [23]A = 4.15.
For the static calculation, a partial safety factor of γ_M = 1.35 must be taken into account for the hose liner material.
The following values must be taken into account in the static calculation:

- Short-term circumferential elastic modulus according to DIN EN 1228[22]: 2,600 N/mm²
- Long-term circumferential elastic modulus: 626 N/mm²
- Flexural stress σ_{fB} according to DIN EN ISO 11296-4[2] or DIN EN ISO 178[10]: 32 N/mm²
- Long-term flexural stress σ_{fB}: 7.7 N/mm²

3.2 Execution

3.2.1 General

Damaged waste water pipes are rehabilitated by introducing and subsequently curing a resin-impregnated polyester synthetic fibre hose with LED or UV light.
For this purpose, a polyester synthetic fibre hose, which is enclosed on the outside with a flexible thermoplastic polyurethane film, is impregnated with vinyl ester resin (VE resin) on site. This hose is folded (inverted) into the pipe to be rehabilitated by means of compressed air using a pressure drum and set up. This inversion causes the thermoplastic polyurethane film to reach the side facing the waste water. The compressed air is maintained until the resin-impregnated polyester synthetic fibre hose has cured.
The hose liner is cured by means of LED light curing or with UV gas discharge lamps.
In the groundwater saturated zone (groundwater infiltration), a PE protective hose (preliner) must always be pulled in before the resin-impregnated polyester synthetic fibre hose is inverted.
The "BRAWOLINER®" hose lining method is possible under the following structural conditions:

a) from the starting shaft to the target shaft
b) from an inspection opening to the target shaft
c) from the starting shaft to the inspection opening
d) from an inspection opening or starting shaft to the waste water collection sewer
e) from the starting shaft or an inspection opening to a defined point in the waste water pipe to be rehabilitated
f) from the sewer to a defined point of the waste water pipe to be rehabilitated

The starting point or target point can be a shaft, an inspection or cleaning opening or an open pipe section. The prerequisite is that the size is sufficient to set up the pressure drum. Several shafts can also be crossed between the respective start and finish points, including the crossing of shafts with channel deflections. Crossings of channel diversions and bends up to 90° can be rehabilitated.

[21]	DIN EN ISO 604	Plastics - Determination of compressive properties (ISO 604:2002); German version EN ISO 604:2003; Edition:2003-12
[22]	DIN EN 1228	Plastics piping systems - Glass-fibre reinforced thermosetting plastic (GRP) pipes - Determination of specific initial ring stiffness; German version EN 1228:1996; Editions 996-08
[23]	DIN EN 761	Plastic piping systems - Glass-fibre reinforced thermosetting plastic (GRP) pipes - Determination of creep factor in the dry state; German version EN 761:1994; Edition: 1994-08

If wrinkling occurs, this must not be greater than that specified in DIN EN ISO 11296-42.
The side inlets are restored from the collecting pipe by means of the "BRAWOLINER connection collar" with the general building approval no. Z-42.3-362.
However, side inlets can also be restored to watertightness either by open construction or by other repair or rehabilitation methods for which general building approvals are valid.
The applicant shall use a manual describing the individual steps to be taken in relation to the type of execution. The manual is filed at the German Institute for Construction Engineering.
The applicant shall also ensure that those executing the work are adequately acquainted with the procedure. The sufficient expert knowledge of the executing company can be documented by an appropriate quality seal issued by Güteschutz Kanalbau e. V. [24].

3.2.2 Devices and equipment

The equipment, components and facilities required as a minimum for the execution of the rehabilitation procedure are:

- Devices for sewer cleaning
- Devices for sewer inspection (DWA-M 149-2[25])
- Rehabilitation equipment/vehicle equipment:
  - Impregnation point, if necessary with suction device
  - Container for residual materials
  - VE resin "BRAWO® LR"
  - If nec. Climatic controlled cabinet for the VE resin system
  - Electric stirrer
  - Polyester synthetic fibre hoses "BRAWOLINER 3D"
  - Roller drive
  - Table with conveyor belt or roller table
  - Power supply with one connector for the light sources
  - Vacuum system
  - LED light source with temperature sensor or UV gas discharge lamps
  - Electrical lines for the transmission of temperature measurement data
  - Temperature measuring sensors
  - If nec. Substitute light sources
  - If nec. Power meter for the substitute light sources (comparison measurement)
  - Nominal diameter-related PE preliners
  - Nominal diameter-related pressure hoses for connection to the pressure drum
  - Pressure drum with pressure monitoring devices and inlet (fibre glass rod Appendix 10) for LED lamps or UV gas discharge lamps and accessories
  - Compressor, compressed air hoses, compressed air regulator (for inversion by means of pressure)
  - Inspection camera
  - Nominal diameter-related translucent calibration hoses (support hoses)
  - Ropes
  - Inversion bends (suitable for the respective nominal diameter)
  - Sealing bags (suitable for the respective nominal diameter)
  - Support tubes or support hoses for sample collection on the construction site (suitable for the respective nominal diameter)
  - Temperature sensor
  - Temperature monitoring and recording apparatus
  - Small devices (e.g. compressed air cutting tools)
  - Hand tools
  - communal and sanitary rooms if necessary

[24] Güteschutz Kanalbau e. V.; Linzer Str. 21, Bad Honnef, Phone: (+49 (0)2224) 9384-0, Fax: (+49 (0)2224) 9384-84

[25] DWA-M 149-2 German Association for Water Management, Waste Water and Waste e. V. (DWA) - data sheet 149: Status detection and assessment of drainage systems outside buildings - Part 2: Coding system for optical inspection; Edition:2011-06

If electrical devices, e.g. video cameras (or so-called long-distance sewer eyes) are brought into the pipeline to be rehabilitated, they must be supplied in accordance with VDE regulations.

3.2.3 Implementation of the rehabilitation measure

3.2.3.1 Preparatory measures

Before commencing work, the waste water pipe to be rehabilitated must be cleaned to such an extent that the damage can be detected faultlessly on the monitor. If nec. obstacles to the inversion of the hose liner must be removed (e.g. root ingrowths, protruding side inlet pipes, tar build-ups, etc.). When removing such obstacles, it must be ensured that this is only done with suitable tools so that the existing waste water pipe is not additionally damaged.

Before starting the inversion it must be ensured that the relevant pipe is not in operation; if necessary, set appropriate sealing bags and divert the waste water.

Persons may only enter shafts of the waste water pipes to be rehabilitated if it has been checked beforehand that no flammable gases are present in the pipe section. The same applies to devices used for the rehabilitation procedure which are to be introduced into the pipeline section to be rehabilitated.

The corresponding sections of the following regulations must be observed:

- GUV-R 126[26] (previously GUV 17.6)
- DWA-M 149-2[25]
- DWA-A 199-1 and DWA-A 199-2[27]

The accuracy of the information referred to in 3.1.1 shall be verified on site. For this purpose, the pipe section to be rehabilitated must be cleaned with conventional high-pressure flushing equipment to such an extent that the damage on the monitor can be detected faultlessly during the optical inspection in accordance with data sheet DWA-M 149-2[25].

When persons enter the shafts of the waste water pipes to be rehabilitated, the relevant accident prevention regulations must also be observed.

When using LED lighting technology or UV gas discharge lamps, the relevant accident prevention regulations must be observed.

The steps necessary for the implementation of the procedure shall be recorded for each rehabilitation using protocol forms.

3.2.3.2 Operating time of the LED lamps and the UV gas discharge lamps

UV gas discharge lamps are to be replaced after an operating time of approx. 350 hours, LED lamps after approx. 600 hours by brand-new UV gas discharge lamps or LED lamps. In addition, the manufacturer's instructions for the light sources must be observed.

3.2.3.3 Incoming inspection of the process components on the construction site

The transport containers used for the process components shall be checked to ensure that the markings referred to in Section 2.2.3 are present.

3.2.3.4 Arrangement of support tubes and support hoses

Before the PE protective hose (preliner) is pulled in, support pipes or support hoses may have to be positioned to extend the waste water pipe to be rehabilitated or in the area of intermediate shafts so that samples can be taken at these points to complete the rehabilitation measure.

3.2.3.5 Positioning of the swelling tapes (auxiliary materials)

Before the preliner is inserted, one or two swelling profiled tapes should be placed at an interval of approx. 10 cm to 20 cm from the beginning of the pipeline to be rehabilitated. These must be positioned by hand. Placing the swelling tapes is also necessary in the same way for each shaft passed through and at the end shaft.

In areas where swelling tapes cannot be used for structural design reasons, the watertight

[26] GUV-R126 Safety regulations: Work in enclosed spaces of waste water treatment plants (previously GUV 17.6); Edition:2008-09

[27] DWA-A 199-1 German Association for Water Management, Waste Water and Waste e. V. (DWA) - Worksheet 199: Service and operating instructions for sewage plant personnel, - Part 1: Service instructions for sewage plant personnel; Edition:2011-11

DWA-A 199-2 German Association for Water Management, Waste Water and Waste e. V. (DWA) - Worksheet 199: Service and operating instructions for sewage system personnel - Part 2: Operating instructions for sewage and rainwater treatment system personnel; Edition:2007-07

formation of the connection areas between the hose liner and the shaft can also be carried out in accordance with Section 3.2.3.12.

3.2.3.6 Installation of the PE preliner

In groundwater saturated zones, a preliner (PE protective hose) must always be inverted. Before the hose liner is installed in the damaged waste water pipe, a PE preliner must be pulled in or inverted. The preliner is designed to prevent resin from the polyester synthetic fibre hose from penetrating through the damaged areas into the surrounding soil. In addition, this is intended to simplify the inversion of the resin-impregnated polyester synthetic fibre hose and prevent excess resin from escaping into the areas of damaged points during subsequent compaction due to the internal pressure applied, thus impairing the target wall thickness at these points.

The PE protective hose must be inserted into the waste water pipe to be rehabilitated in such a way that damage is avoided. The PE protective hose must be installed by means of inversion. The PE protective hose must be inserted into the waste water pipe to be rehabilitated using the "pressure drum" by means of compressed air. The swelling tapes to be used for the watertight connection of the hose liner must be positioned in the area of the shaft connections when the PE protective hose is installed (Appendix 11).

3.2.3.7 Resin impregnation Appendix 3

The delivered hoses must be cut to length on site according to the respective segment lengths. The hoses may only be impregnated at the construction site in special production vehicles provided for this purpose, including roller drives and a vacuum system. The entire work area for impregnation must be protected from daylight (UV light). Lighting must be used whose radiation does not reach the wavelength range from λ = 360 nm to λ = 450 nm. The resin temperature must be between +15 °C and +25 °C during impregnation. The VE resin system must be homogenised by means of an electric stirrer.

To prepare the resin impregnation, the respective hose liner end must be sealed airtight. The filler hose or funnel for the resin system must be placed at this point beforehand. The air is largely to be evacuated from the inside of the hose liner by means of the vacuum device located in the vehicle. The vacuum must be applied at least 5 minutes before resin impregnation. To do this, an incision of max. 1 cm is to be cut into the top coating. The suction nozzle of the vacuum system is now to be placed on this incision. A corresponding vacuum of approx. 0.5 bar must be generated in the hose liner.

To fill the resin into the hose liner, use a filler funnel or hose that has been previously attached to the end of the hose liner. The hose liner must be filled with the required quantity of resin. This should be done either by means of a pump or by means of hydrostatic pressure. The filling process is supported by the pressure in the hose liner of approx. 0.5 bar.

The quantity of resin required shall be determined in accordance with Appendix 2.

After filling, the soaked hose liner must be passed through an appropriate roller drive so that the polyester synthetic fibre layer is evenly soaked. The required roller spacing can be found in Appendix 2.

The feed rate must be selected so that the resin is distributed as evenly as possible in the matrix of the polyester synthetic fibre hose. The speed of the impregnation process depends on the absorption and penetration behaviour of the resin mixture. If the resin distribution is noticeably uneven, the hose liner may have to be passed through the roller drive again with a narrower distance between the rollers. After even distribution of the resin quantity in the hose liner, the cutting opening on the hose liner must be sealed airtight.

Immediately after impregnation, the hose liner must be rolled up in the pressure drum to be provided or stored in a light-tight container. The inversion of the hose liner must be carried out in accordance with Section 3.2.3.8.

The quantity of resin processed and curing process must be recorded.

3.2.3.8 Inversion of the resin-impregnated hose liner

First the preliner has to be retracted or inverted. The preliner is inserted by means of a winch or compressed air.

The PE preliner is designed to prevent resin from the polyester synthetic fibre hose from getting through the damaged areas into the surrounding soil.

Compressed air inversion of the resin-impregnated hose liner by means of a pressure drum

a) Close-end inversion (close-end process) Appendix 7

The pull-in rope must be attached to the closed end of the impregnated hose liner. The pull-in rope must be connected to the pressure drum. By means of this rope, the hose liner is rolled up in the pressure drum (Appendix 4).
A nominal diameter-related pressure hose is to be connected to the pressure drum by means of coupling elements. At the other end of the pressure hose, an inversion pipe matched to the pipe to be rehabilitated must be attached by means of a coupling element. The end of the hose liner must be pulled through the pressure hose and turned inside out at the inversion pipe. This hose liner end must be firmly connected to the inversion pipe by means of adhesive tapes and, if necessary, metallic tensioning straps.
The inversion pipe (inversion bend) with the hose liner end must be inserted in the start shaft or in front of the inspection opening and, if necessary, positioned in the PE protective hose (preliner) at the beginning of the pipe to be rehabilitated (Appendix 10).
An inversion pressure of 0.2 bar to 0.3 bar must then be applied to the pressure drum. The resin-impregnated hose liner is pressurised with compressed air and this causes the turning inside out process. This inversion process continues until the target shaft, the inspection opening or the target point of the waste water pipe to be rehabilitated is reached. This process brings the resin-impregnated inside of the hose liner either into contact with the inside of the PE preliner or directly into contact with the inner surface of the waste water pipe to be rehabilitated. In this way, the thermoplastic TPU coating reaches the side facing the waste water.

b) Inversion with open end (open-end method) Appendices 5 and 6
If the rehabilitation is carried out from a start shaft or an inspection opening in the direction of an inaccessible waste water collection sewer, the hose liner length must first be determined so that the hose liner does not protrude into the collection sewer. The end of the hose liner must be sealed with a retaining rubber before it is rolled up in the pressure drum.
The hose liner sealed in this way must be rolled up in the pressure drum. After that, the same steps as described in paragraph (a) shall be carried out, including inversion. At the end of the inversion process supported by compressed air, the retaining rubber loosens and the pressure in the hose liner is released. The hose liner is not yet placed against the inner surface of the pipe to be rehabilitated or against the PE protective pipe (preliner) previously installed.
The hose liner must be detached from the inversion pipe. A PVC calibration hose must be rolled into the pressure drum. The other end of this calibration hose shall be attached to the U-bend together with the exposed end of the resin impregnated liner. Then the calibration hose must be inverted at the same pressure level as mentioned in paragraph (a). The calibration hose ensures that the hose liner fits snugly against the inner surface of the pipe to be rehabilitated or the PE preliner.

3.2.3.9 Curing the hose liner

The hose liner is cured either by LED light with a wavelength range from λ = 360 nm to λ = 450 nm (min. 100 W to ≤DN 150 and min. 200 W from nominal diameter ≥DN 150) or by UV gas discharge lamps with a wattage of at least 3x100 W to ≤DN 150 and at least 3x200 W from nominal diameter ≥DN 150.
After the inversion of the hose liner in accordance with Section 3.2.3.8 (close-end procedure and open-end procedure), the LED lamps or UV gas discharge lamps including temperature sensors shall be inserted via a side feed with port (fibre glass rod Appendix 10) at the pressure drum with the aid of a push-in cable and pushed forward to the top end. The LED light source or UV gas discharge lamps must be switched on and pulled through the hose liner controlled by electrically driven rollers. The LED lamps or UV gas discharge lamps must be pulled through the hose liner at the speeds specified in Appendix 9.
In the case of rehabilitation with an open-end method, the calibration hose (support hose) is inverted back after curing the hose liner and the protruding end is cut off at the beginning of the installation.
The control and monitoring of the LED lamps or the UV gas discharge lamps is carried out via a monitor. The internal pressure in the hose liner (0.3 bar to 0.4 bar), the speed of the LED lamps or the UV gas discharge lamps (Appendix 8), the wavelength range or power (current strength) and temperature of the LED lamps and the visual transmission of the

rehabilitation section where the LED lamps or the UV gas discharge lamps are located are displayed. The recorded parameters must be continuously and permanently recorded by the control unit.
If the temperature of the LED lamps rises above +70 °C, this is automatically switched off to prevent damage to the light sources.
The curing time depends on the nominal diameter and wall thickness of the pipe liner as well as on the drawing speed of the LED lamps or UV gas discharge lamps used. The curing time can be controlled by the drawing speed of the lamps.
The curing speed, the internal pressure of the hose liner, the temperature, the wavelength of the LED lamps, the electrical power of the UV gas discharge lamps, the LED or UV lamp brightness, the drawing speed and the curing time must be recorded and documented during curing of the hose liner (e.g. Appendix 13).
After curing, the pressure in the hose liner must be maintained for a further 10 minutes in order to lower the temperature to approx. +40 °C. The pressure can then be released and the hose liner separated from the pressure drum.

3.2.3.10 Final work

After curing, the resulting inner pipe on the respective shaft wall must be cut off and removed using compressed air-powered cutting tools in the start and target shafts. In the intermediate shafts, the upper half-shell of the resulting pipe must be removed until it touches the floor of the shaft.
The pipe sections (circular rings) are to be taken from the support pipes or support hoses also to be removed (see Section 3.2.4) for the following tests.
When carrying out cutting work, the relevant accident prevention regulations must be observed.

3.2.3.11 Reconnection of side inlets

The side inlets are restored from the collecting pipe by means of the "BRAWOLINER connection collar" with the general building approval no. Z-42.3-362.
However, side inlets can also be restored to watertightness either by open construction or by other repair or rehabilitation methods for which general building approvals are valid.

3.2.3.12 Shaft connection

Shaft connections must be watertight using swelling auxiliary tapes (Appendix 11), which must be positioned in the area of the shaft connections before the PE protective hose (preliner) is pulled in.
The resulting protrusions (see also Section 3.2.3.10 - Final work) of the cured inner pipe facing the front wall of the shaft (so-called mirror) and the transitions to the flow channel in the start and target shaft must be made watertight both in the respective start and, if necessary, also in the target shaft, as well as in the intermediate shafts.
Shaft connections are to be made watertight using swelling auxiliary tapes positioned in the area of the shaft connections.
In areas where swelling tapes (auxiliary tapes) cannot be used for structural design reasons, the watertight formation of the connection areas between the hose liner and the shaft after curing the hose liner can also be carried out as follows (Appendix 12):

a) Connection of the hose liners by means of a reaction resin putty, for which a general building approval is valid,
b) Connection of the hose liners by means of mortar systems for which a general building approval is valid,
c) GRP laminates for which a general building approval is valid,
d) Pressing with polyurethane (PU) or epoxy (EP) resins for which a general building approval is valid,
e) Installation of hose liner end sleeves for which a general building approval is valid.

The proper execution of the watertight design of the transitions must be ensured.

3.2.3.13 Inscription in the shaft

The following inscription should be applied in the start or end shaft of the rehabilitation measure in a permanent and easily legible manner:

- Type of rehabilitation
- Designation of the pipe section
- Nominal diameter
- Wall thickness of the hose liner

- Year of rehabilitation

3.2.3.14 Final inspection and leak test

After completion of the work, the rehabilitated pipe section must be inspected visually. It must be determined whether any material residues have been removed and whether there are any hydraulically detrimental folds.

After curing the hose liner, including the production of the shaft connections and the restoration of the side inlets, it must be checked for leaks. This can also be done in sections. The rehabilitated pipes must always be checked for leaks using water (procedure "W1") in accordance with DIN EN 1610[28] (Appendix 14). Rehabilitated side inlets can also be tested separately for watertightness using suitable sealing bags.

In the nominal diameter range DN 100 to DN 225, rehabilitated pipes can also be tested with air (method "L") according to the specifications in Table 3 of DIN EN 1610[28], test method LB for dry concrete pipes.

3.2.4 Tests on samples taken

3.2.4.1 General

Circular rings or segments shall be taken from the cured circular hose liner in the inaccessible area (see specifications for "Sample hoses" in Section 3.2.3.4) on the construction site (Appendix 15).

If it turns out that the samples are unsuitable for the tests specified under Section 3.2.3.4, or if it is not possible to take samples from circular rings or segments, the properties to be complied with can be checked on samples taken directly from the cured hose liner (diameter of sample approx. 5 cm) (drill core removal).

3.2.4.2 Strength properties

Determination of the strength properties after 3-point flexural and long-term ring stiffness testing:

The flexural elastic modulus and the flexural stress σ_{fB} are to be determined from the samples or circular segments taken. During these tests, the respective 1-minute values shall be recorded. If the value falls below the short-term value for the respective elastic modulus according to Section 3.1.2.1.2, the 1-hour value and the 24-hour value of the flexural elastic modulus must be determined.

The test shall also determine, taking into account the 1-hour elastic modulus and the 24-hour elastic modulus, whether the creep tendency is maintained according to DIN EN ISO 899-2[29] in accordance with the following relationship:

$$K_n = \frac{E_{1h} - E_{24h}}{E_{1h}} x100$$

Kn $\leq$ 20 % sample age 7 days
Kn $\leq$ 20 % sample age 14 days
Kn $\leq$ 19 % sample age 28 days

If the lower limit value of the short-time elastic modulus specified in Section 3.1.2.1.2 falls below the tested short-time elastic modulus value, the creep tendency shall be checked. It shall also be checked once per month of production.

The flexural elastic modulus and the flexural stress σ_{fB} must be determined on the cured hose liner according to DIN EN ISO 11296-4[2] or DIN EN ISO 178[10] (three-point flexural test).

In this case, curved test bars from the corresponding circular profile are to be used, which have been removed from the segments in the radial direction with a minimum width of 50 mm. When testing and calculating the elastic modulus, the span measured between the support points of the test bar shall be taken into account.

The determined short-term values of the elastic modulus and flexural stresses σ_{fB} must be equal to or greater than the value specified in Section 3.1.2.1.2 and Section 3.1.2.1.3.

When changing the resin supplier, the 2-minute value, the 1-hour value and the 24-hour value of the ring stiffness must also be recorded on the removed circular rings. The ring stiffness test shall be carried out in accordance with the procedure described in DIN 53769-

[28] DIN EN 1610 Installation and testing of waste water pipes and sewers; German version EN 1610:2015; Edition:2015-12

[29] DIN EN ISO 899-2 Plastics - Determination of creep behaviour - Part 2: Creep rupture flexural test under three-point loading (ISO 899-2:2003); German version EN ISO 899-2:2003; Edition:2003-10

3[30] or DIN EN 1228[22]. The creep tendency must also be determined.

3.2.4.3 Watertightness

The watertightness of the cured hose liner can either be carried out on a hose liner section (circular ring) without protective film or on test pieces taken from the cured hose liner without film coating. For the test, the film on the hose liner section or test piece shall either be removed or perforated.

Testing on test pieces may be carried out either with overpressure or a vacuum of 0.5 bar. During the vacuum test, water shall be applied to one side of the sample. At a vacuum of 0.5 bar, no water leakage shall be visible on the unloaded side of the sample for a test period of 30 minutes.

In the overpressure test, a water pressure of 0.5 bar shall be applied for 30 minutes. With this method, too, no water leakage must be visible on the unloaded side of the sample.

3.2.4.4 Wall thickness and wall construction

The average and total wall thickness as well as the wall construction according to the conditions in Section 3.1.2.1.1 shall be checked on cut surfaces, e.g. using a light microscope with approx. 10-fold magnification. The thickness of the pure resin layer must also be checked. In addition, the average area of any shrink hole points shall be checked in accordance with DIN EN ISO 7822[31].

3.2.4.5 Physical characteristics of the cured hose liner

The characteristic values specified in Sections 3.1.2.1.2 and 3.1.2.1.3 shall be checked on the samples taken.

3.2.5 Declaration of compliance with the rehabilitation measure carried out

The confirmation of conformity for the rehabilitation work carried out with the provisions of this general type approval shall be made by the operating company with a declaration of conformity on the basis of the specifications in Tables 2 and 3. The declaration of conformity shall be accompanied by documentation of the characteristics of the process components referred to in Section 2.1.1 and by the results of the tests referred to in Table 2 and Table 3.

The manager of the rehabilitation measure or a competent representative of the manager must be present on the construction site during the execution of the rehabilitation. He shall ensure the proper execution of the work in accordance with the provisions of Section 3.2 and, in particular, carry out the tests in accordance with Table 2 or arrange for them and the tests in accordance with Table 3 to be carried out. The number and scope of the specifications listed are minimum requirements.

The tests on samples in accordance with Table 3 shall be performed by an inspection body recognised by the building supervisory authority (see list of inspection, testing and certification bodies in accordance with the state building regulations, Part V, No. 9).

Once every six months, the sampling from a hose liner of an executed rehabilitation measure must be carried out by the aforementioned monitoring body. The latter shall also review the documentation of the work carried out according to Table 2 of the rehabilitation measure.

Table 2: "Procedure-accompanying tests"

Object of the test	Type of requirement	Frequency
optical inspection of the pipe	according to Section 3.2.3.1 and DWA-M 149-2[25]	before every rehabilitation
optical inspection of the pipe	according to section 3.2.3.14 and DWA-M 149-2[25]	after every rehabilitation
Instrumentation	according to Section 3.2.2	every construction site
Marking of the containers for the rehabilitation components	according to Section 2.2.3	
Air and watertightness	according to Section 3.2.3.14	
Resin quantity per hose liner	Sections 2.2.1.1 and 3.2.3.7	
Curing behaviour	according to Section 3.1.2.1	

30 DIN 53769-3 Testing of pipelines made of glass-fibre reinforced plastics; initial and long-time ring stiffness test on pipes; Edition:1988-11

31 DIN EN ISO 7822 Textile glass reinforced plastics - Determination of the amount of shrink holes present - Annealing loss, mechanical decomposition and statistical evaluation methods (ISO 7822:1990); German version EN ISO 7822:1999; Edition:2000-01

	and Section 3.1.2.1.2
Curing temperature and curing time	according to Section 3.2.3.9

The tests listed in Table 3 shall be initiated by the manager of the remediation measure or his expert representative. For the tests specified in Table 3, samples shall be taken from the sample hoses described.

Table 3: "Tests on samples"

Object of the test	**Type of requirement**	**Frequency**
Initial flexural elastic modulus, initial flexural stress σ_{fB} and creep tendency at pipe cut-outs or at circular rings	according to Section 3.2.4.1 and Section 3.2.4.2	every construction site, min. every second hose liner
Density of the sample without preliner and without coating film	according to Section 3.2.4.5	
Watertightness of samples without PE preliner and without thermoplastic TPU coating film	according to Section 3.2.4.3	
Wall construction	according to Section 3.2.4.4	
Creep tendency at pipe sections or cut-outs	according to Section 3.2.4.2	if the value falls below the initial modulus of elongation specified in Section 3.1.2.1.3 and at least once every six months

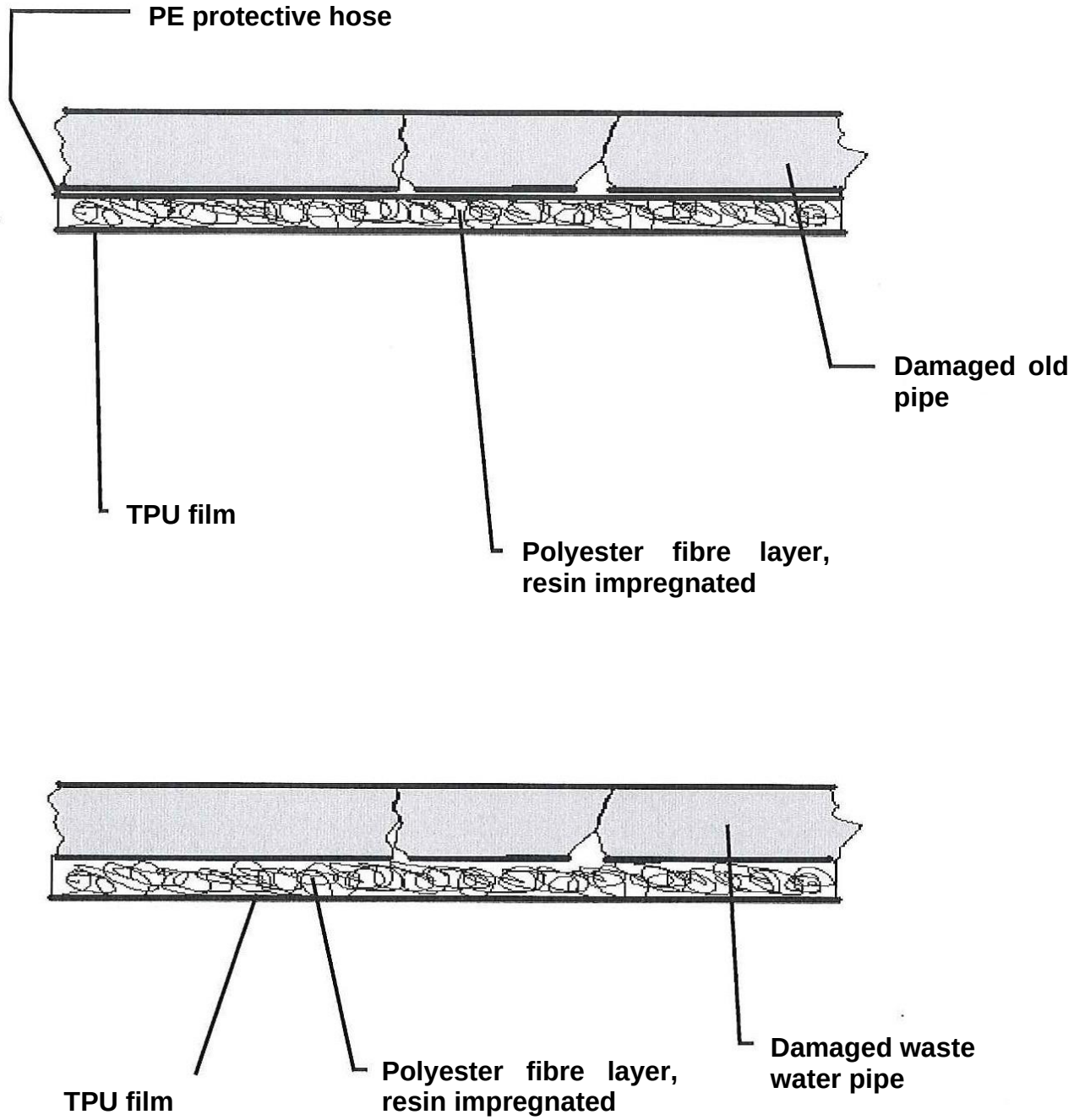
The test results shall be recorded and evaluated; they shall be submitted to German Institute for Construction Engineering on request. The number and scope of the specifications listed in Tables 2 and 3 are minimum requirements.

4 Provisions for use, maintenance and servicing

During the period of validity of this approval, the applicant shall visually inspect six rehabilitated waste water pipes. The results, together with a description of the rehabilitated damage, shall be submitted to the German Institute for Construction Engineering without being requested to do so during the period of validity of this approval.

Rudolf Kersten
Head of unit

Certified [Stamp]
[Signature]



Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 1

Wall construction

Resin consumption

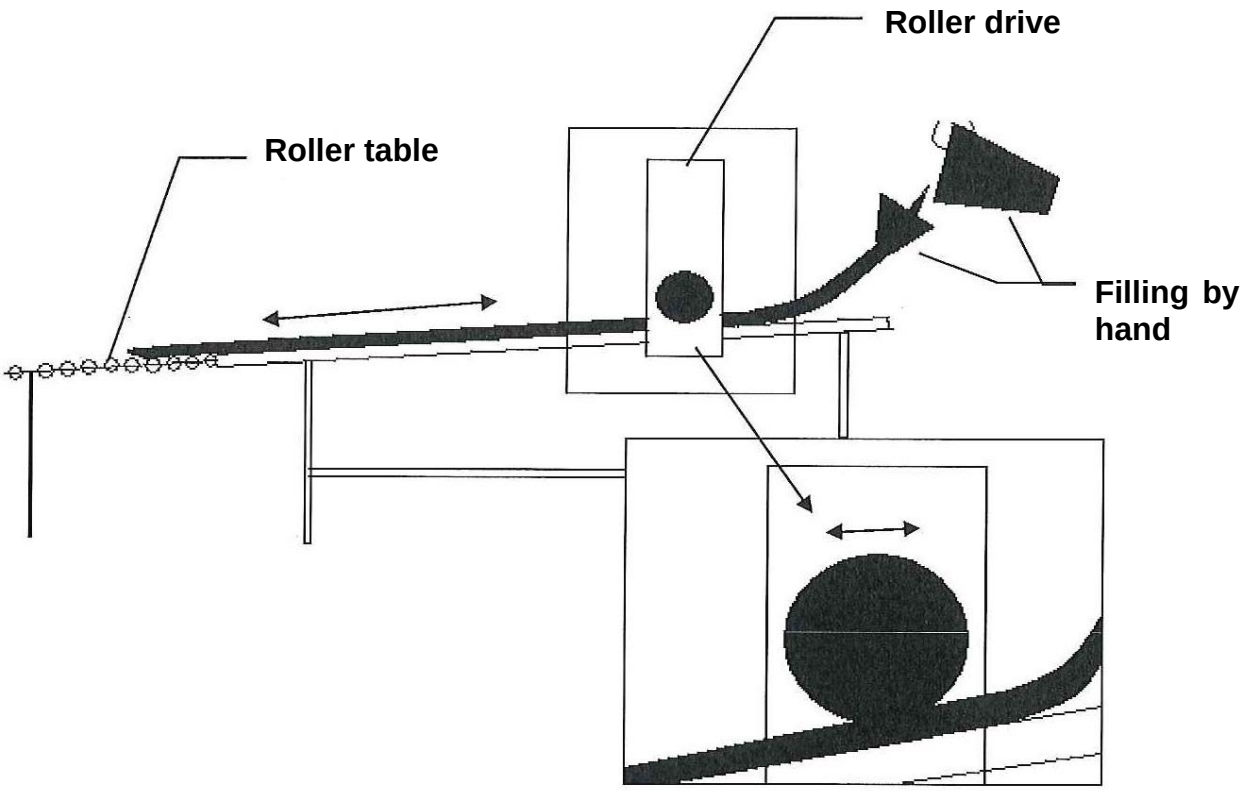
BRAWOLINER®3D

N	Roller spacing on impregnation system	BRAWO LR in kg / linear m.	Volume in litres / linear m.
100-150	12 mm	1.5	1.46
150-225		2.3	2.09

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 2

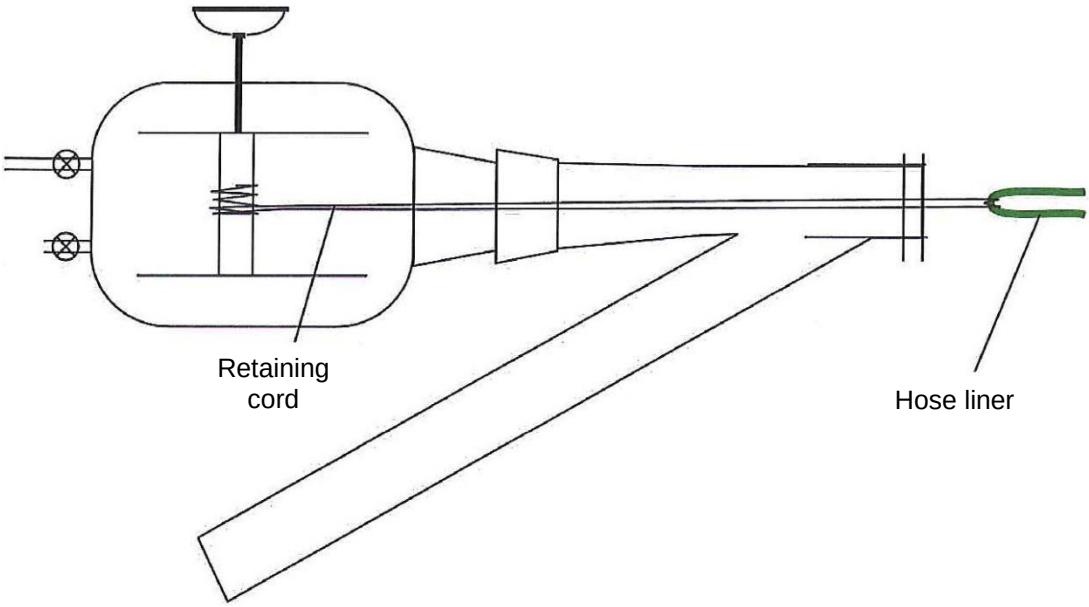
Resin consumption

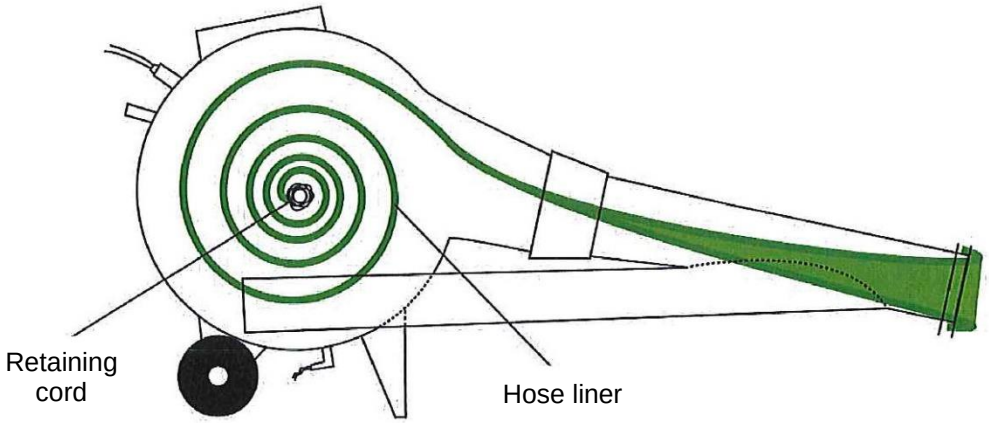


Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 3

Hose liner is impregnated / rolled

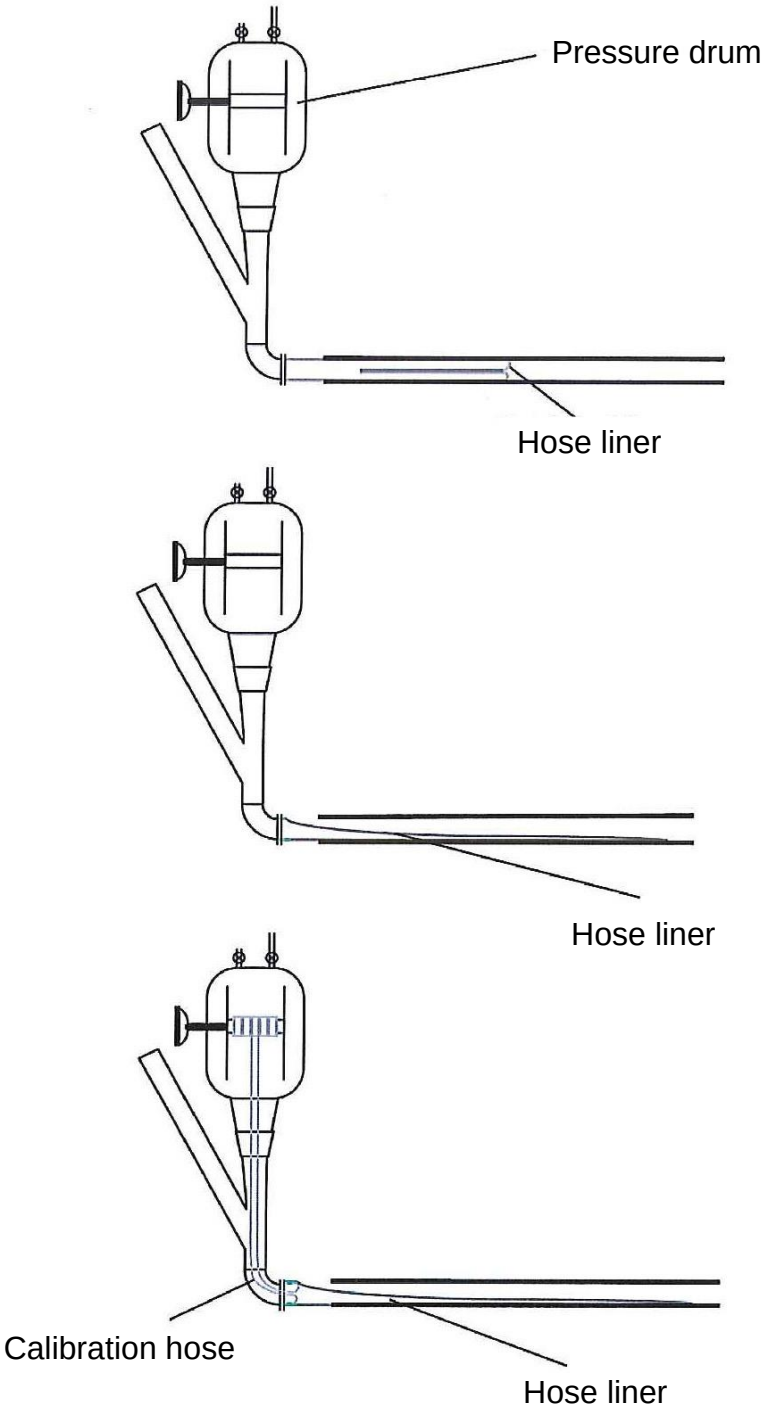




Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 4

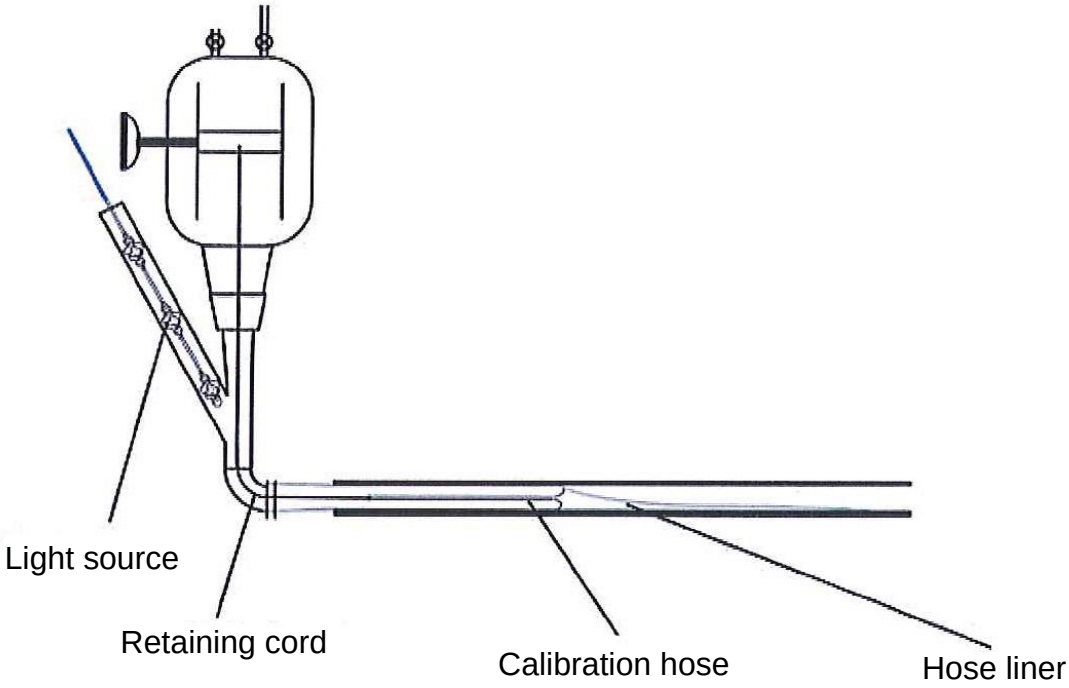
Pulling the hose liner into the pressure drum

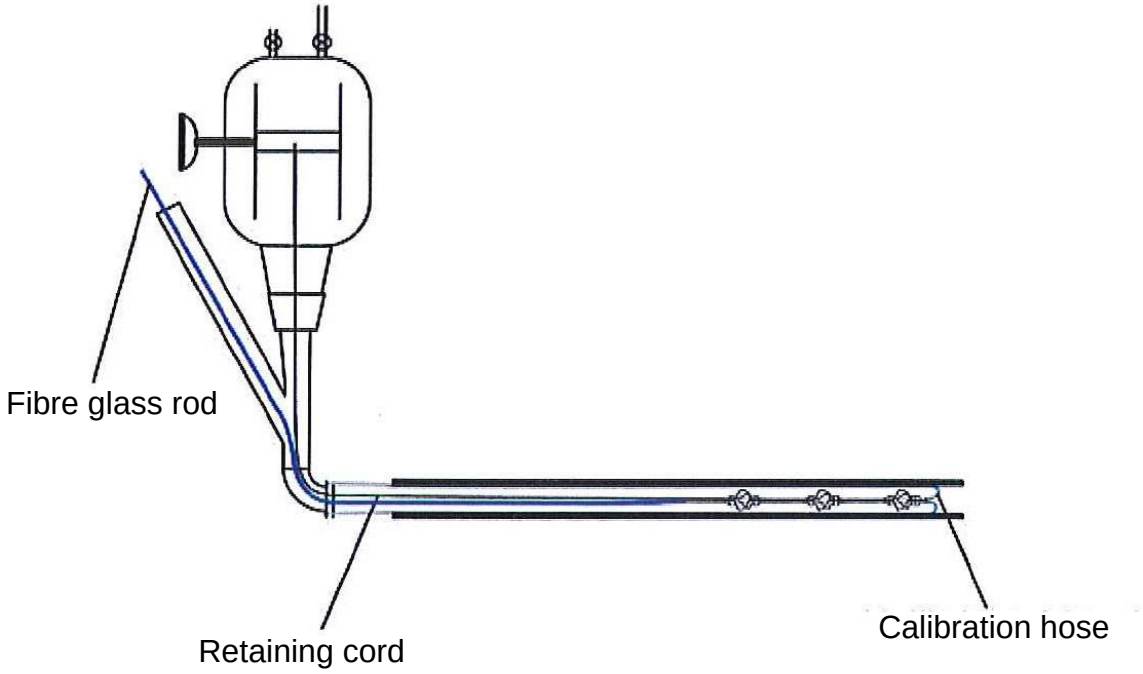


Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 5

Inversion with open end part 1/2

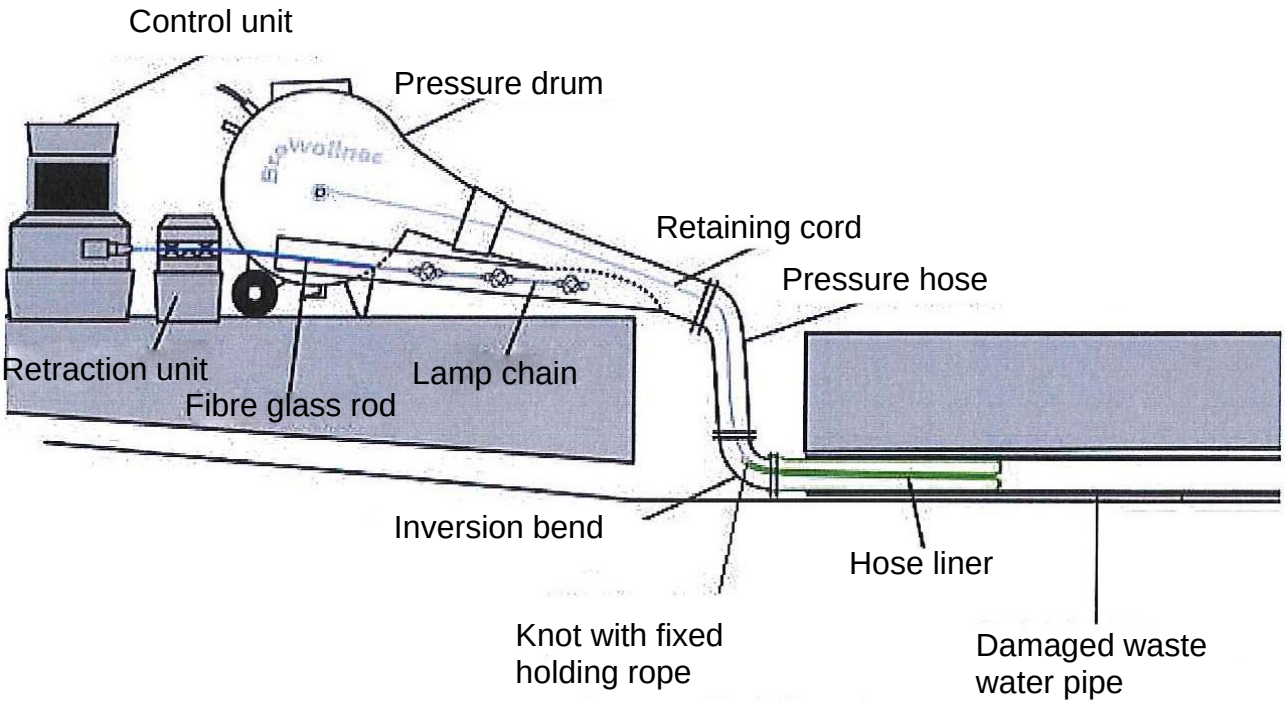




Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 6

Inversion with open end Part 2/2

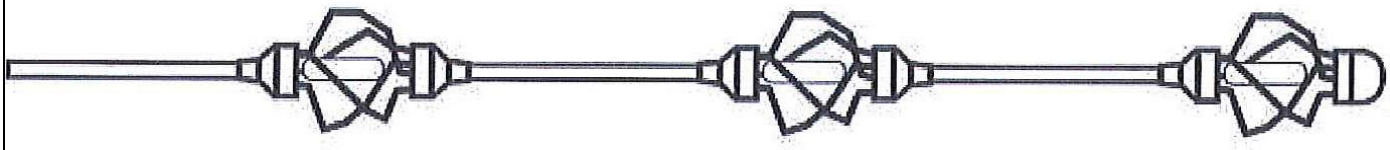


Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 7

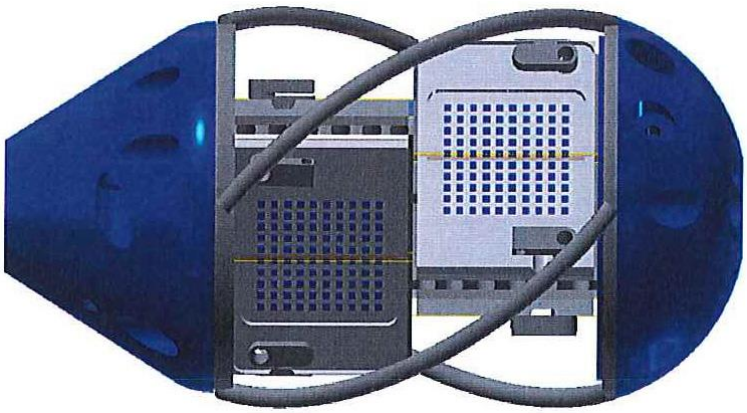
Inversion with closed end

Gas discharge lamps:



Composition of a lamp train made of gas discharge lamps for UV light curing
Power min. 300 W (e.g. 3x100 W) for DN100-150 and min. 600 W (e.g. 2x200 W) for >DN150-225 Wavelength range 360-450 nm

LED lamp:



Composition of an LED lamp for light curing
Power min. 300 W for DN100-225, wavelength range 360-450 nm (typical 400 nm)

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 8

UV gas discharge lamps and LED lamp

Curing speeds

BRAWOLINER® 3D

Liner type	Pipe dimension DN	Curing speed in m/min	
		Closed end	Open end
DN100-150	100	0.6	0.4
DN100-150	125	0.5	0.3
DN100-150	150	0.4	0.2
DN150-225	150	0.4	0.2
DN150-225	200	0.3	0.2

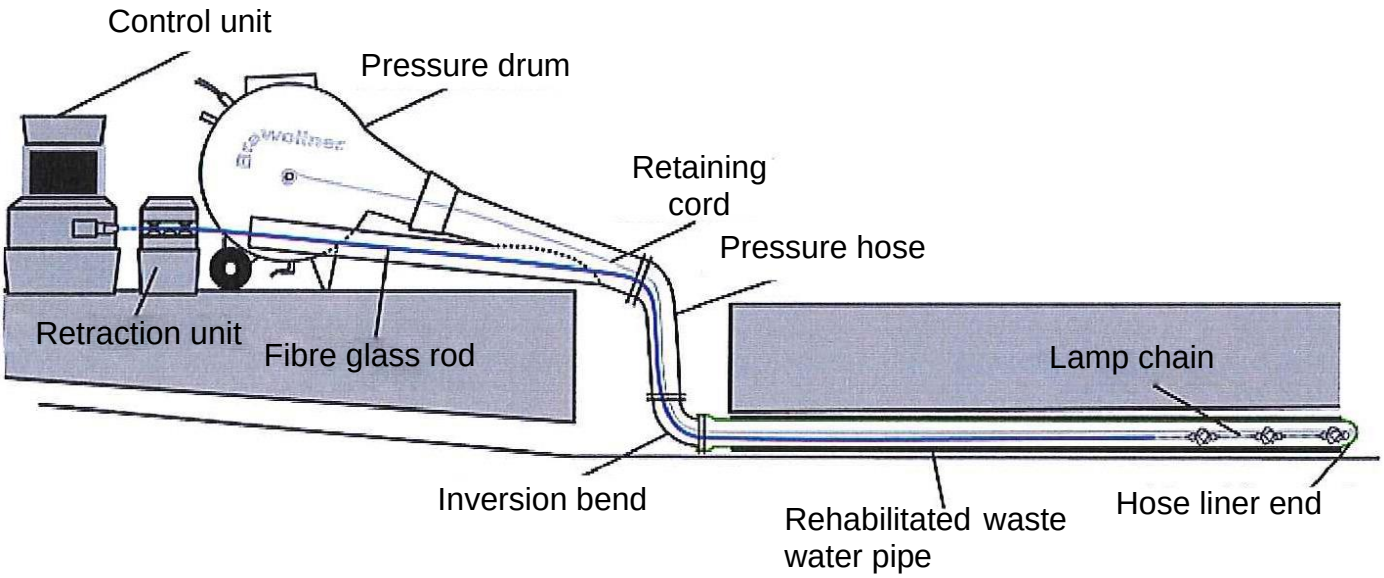
The specifications apply when using a BRAWO LumiWave system with 3 x 200 W gas discharge lamps or a UV relining system with a 600 W LED head.

All data is to be understood as approximate and is based on experimentally determined values.

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 9

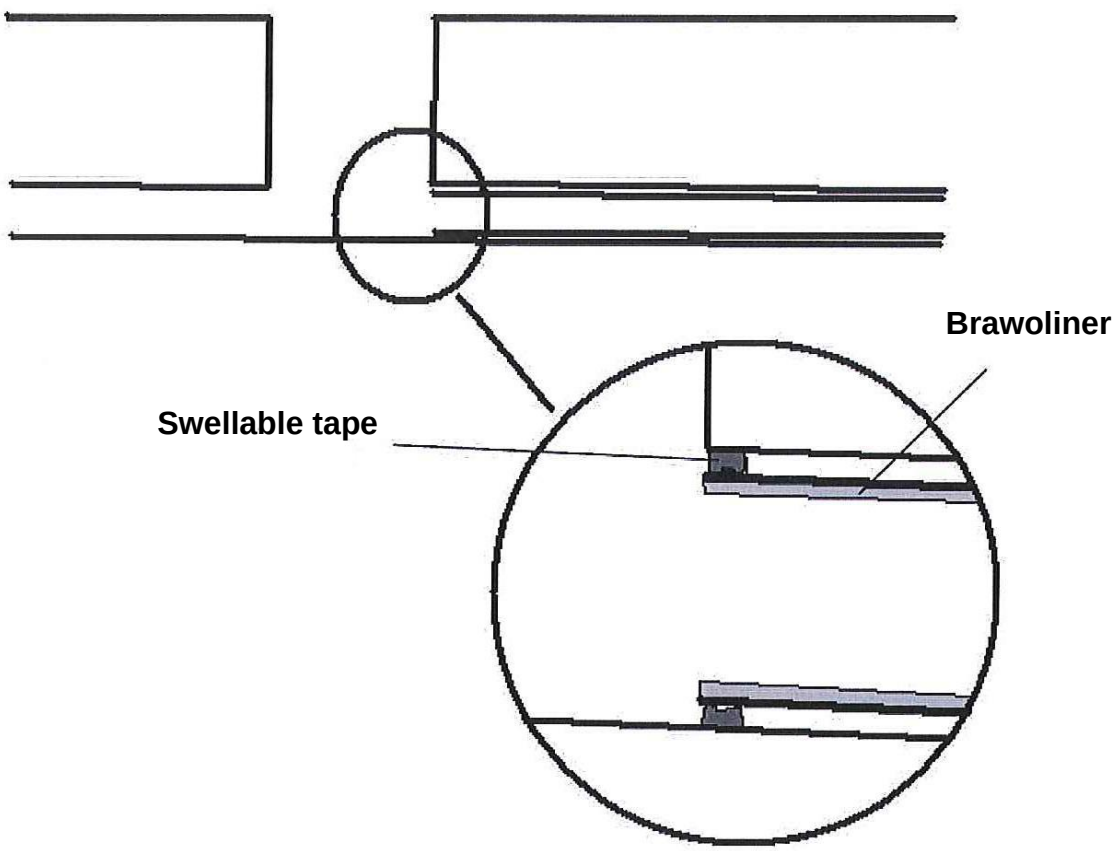
Pulling through speeds



Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 10

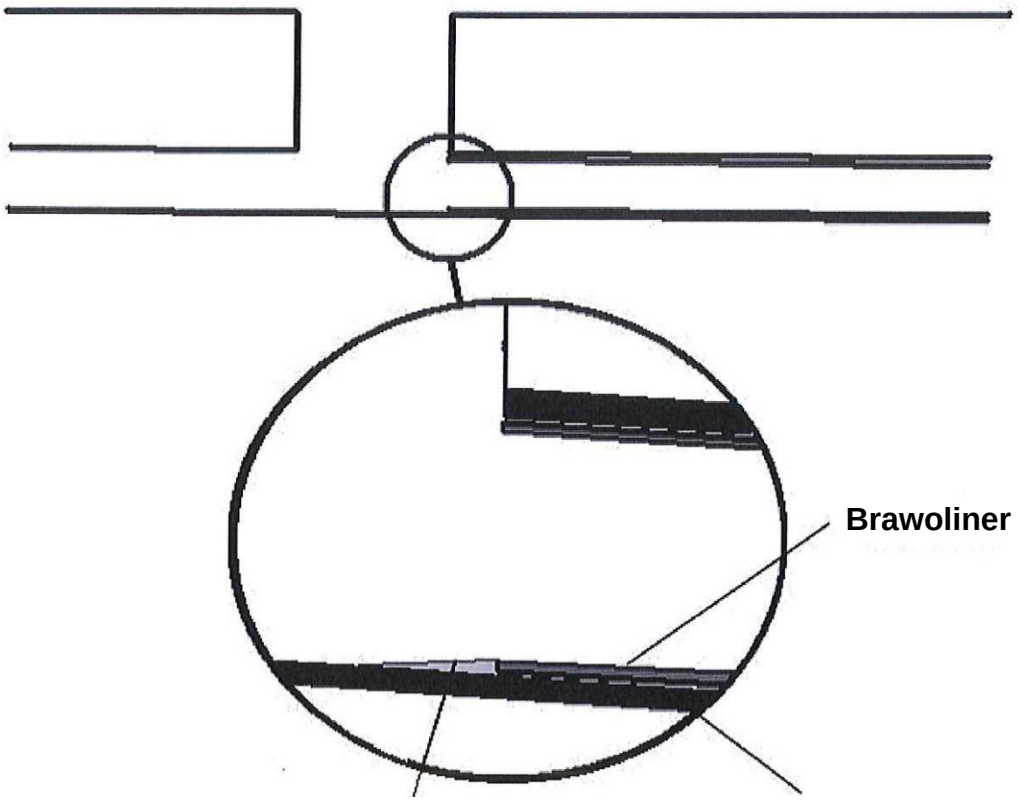
Curing with light



Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 11

Swelling tape



a) Connection of the liners by means of reaction resin filler, for which a general building approval is valid,

b) Connection of the liners by means of mortar systems for which a general building approval is valid,

c) GRP laminates for which a general building approval is valid,

d) Pressing with polyurethane (PU) or epoxy (EP) resins for which a general building approval is valid,

e) Installation of hose liner sleeves for which a general building approval is valid.

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 12

Shaft connections

Installation protocol for BRAWO LumCure			Sheet:	Weather	Head of operations		
			Date:	Temperature	Personnel:		
				Precipitation:	Kol. vehicle:		
Operation site			Client		Construction site number:		
TV preliminary examination (*circle which applies)	YES*	NO*	HD cleaning	YES	NO	Cordon off for the day	YES / NO
TV follow-up inspection	YES	NO	Calibration	YES	NO	Milling work	YES / NO
DN:	Length:		Material:			From shaft:	To shaft:
Shaft depth in [m]:			Position:			Diameter in [m]:	
Drop (height difference) in [m]:			Type of damage:			Number / position of inlets:	
Bends:							
Material	Material determined by	Client ☐	Contractor/construction supervisor	☐ Contractor/ foreman	☐ Comments:		
Liner	Brawoliner ☐ Brawoliner XT ☐	Brawoliner 3D ☐ Connection collar ☐		Nominal diameter DN: / Batch number of cardboard:		**Resin** BRAWO LR	Batch no.:

Installation						
Prefiner used		YES	NO	*Comments:*		**Sketch**
End	Open	Sleeve	For			
Calibration hose		YES	NO			
Sewage-free?		YES	NO			
Resin storage temperature (SETPOINT: 5°C - 25°C):			°C			
Resin temperature before installation (SETPOINT: 15°C-20°C)			°C			
Quantity of resin in [kg/m]:				Total [kg]:		
Stirred / Homogenised		YES	NO	Roller spacing: mm		
Impregnation	On the construction site ☐			Pre-impregnated ☐		
Inversion pressure (SETPOINT: 0.2 - 0.3 bar):			bar			
Curing						
Curing conditions:	UV system used			BRAWO LumCure ☐	UV relining ☐	Other:
	Number & power of UV lamps			3x200W ☐	1 x 600W ☐	Other:
Retraction speed	Setpoint:		m/min	Actual: m/min		
Curing pressure (SETPOINT 0.3 - 0.4 bar):			bar			

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Installation protocol

Appendix 13

PROTOCOL FOR TESTING WASTE WATER PIPES FOR LEAKS in accordance with DIN EN 1610

1. Details of the construction plan:

Construction plan:			
Address:		Postcode/Town:	
Client:			
Address:		Postcode/Town:	
Rehabilitation company:			
Address:			
Manufacturer type:	o Hose liner o Short liner	Product name:	
Leak test:			
Address:		Postcode/Town:	

2. Details of the sewer / sewer pipe:

Type of waste water:	o Wastewater	o Rainwater		o Mixed water	
Pipe shape:	o Circular profile	o Oval profile			
Liner material:		Nominal diameter:		Rehabilitation date:	
Segment number:					
Segment length:					
From shaft:		to shaft:			

3. Leak test with air:

Test method:	o LA		o LB	o LC	o LD
Test pressure p_0:		mbar	Settling time:		mbar
perm. pressure drop Δp:		mbar	Test duration.		mbar
Pressure at the beginning:		mbar			
Pressure at the end:		mbar	Pressure drop:		mbar

4. Leak test with water:

o pipelines only	o shafts and inspection openings	o pipeline with shaft
Test duration:		30 min
The height of the water column above the top of the pipe at the start of the test:		kPa (= mWS - 10)
Water addition:		l
Water addition / segment length;		l/m²
Permissible addition of water per m² of wetted area according to DIN EN 1610:		0.15 l/m²
Calculated permissible total addition of water in relation to the test length:		l
actual addition of water:		l

5. Result

Test passed:	o yes	o no	
Comments:			
Place/Date:		Signature:	

Hose liner with the designation "BRAWOLINER®" for the rehabilitation of defective underground waste water pipes in the nominal diameter range from DN 100 to DN 225 with LED or UV light curing

Appendix 14

Leak test DIN EN 1610

TEST CERTIFICATE FOR MATERIAL TESTING OF HOSE LINERS

☐ *INITIAL TEST* ☐ *REPEAT TEST* *for test report no:*

1. Sampling information:

taken by:		Testing institute	
Date: / Time:		Address:	

2. Sample identification:

Construction plan:			Material ID:			
Client.			Sample designation:			
Cost centre:			Segment designation:			
Executing company:			Nominal diameter:			
Manufacturer of hose liner.			Installation date:			
Carrier material:			Old pipe condition:	o I	o II	o III
Resin material:			Sampling point:	o Segment	o End shaft	o Interm. shaft
Pipe geometry:	o Circular profile	o Oval profile	Sampling position:	o Vertex	o Transom	o Sole

3. Required initial properties according to static proof:

Flexural modulus of elongation$_{DIN}$ E_f [N/mm²]:		Circumferential modulus of elongation E_u [N/mm²]:	
Flexural stress $_{\text{at first rupture}}$ σ_{rB} [N/mm²]:		Initial ring stiffness S_0 [N/m²]:	
Wall thickness **d** [mm]:		max, creep tendency K_{N24} (%):	
Reduction factor A_t:		Density **δ** [g/cm³]:	

4. Test results:

Flexural modulus of elongation, flexural stress DIN EN ISO 178/ DIN EN ISO 11296-4

☐	Test date	E_f [N/mm²]	σ_{rB} [N/mm²]	h [mm]
		Test direction:	o axial	o radial

24 h creep tendency according to DIN EN ISO 899-2

☐	Test date	K_N [%]

Circumferential modulus of elongation, initial ring stiffness according to DIN EN 1228

☐	Test date	E_u [N/mm²]	S_0 [N/mm²]	h [mm]

24 h creep tendency according to DIN EN 761

☐	Test date	K_N [%]

Watertightness according to DIN EN 1610

☐	Test date	Test time	Test pressure [bar]	Test result	
		30 minutes		o tight	o leaky

Calcination process according to DIN EN ISO 1172

☐	Test date	Resin content [%]	Total residue [%]	Glass content [%]	Aggregate [%]

Spectral analysis according to ASTM D 6576 (FT-IR)

☐	Test date	EP resin	UP resin	VE resin	other Resin

Density according to DIN EN IS01181-1 or -2

☐	Test date	δ [g/cm²]

Thermal analysis according to DIN EN ISO 11357-1 / DSC analysis DIN 63765 Method A

☐	Test date	Glass transition temperature [°C]			Enthalpy [J/g]	
		T_{G1}		ΔT_G		
		T_{G2}			o exothermic	o endothermic

Residual styrene content according to DIN 63394-2 (GC)

☐	Test date	Weight of sample taken [mg]	Residual styrene content [mg/kg]	Residual styrene content [%]	Weight of sample taken in relation to	
					o Total sample weight	o Pure resin

5. Evaluation of the results:

Requirements	fulfilled	not fulfilled
Flexural modulus of elongation E_f	o	o
Flexural stress σ_{rB}	o	o
Wall thickness **d**	o	o
Watertightness	o	o

Requirements	fulfilled	not fulfilled
Circumferential modulus of elongation E_u	o	o
Initial ring stiffness S_0	o	o
24 h creep tendency K_N	o	o
Density **δ**	o	o

6. Comments:

7. Signature tester / laboratory:

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Appendix 15

Certificate accompanying sample