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National technical approval / General construction technique permit

Approval body for construction products and techniques

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from: **1 February 2022**
to: **1 February 2027**

Applicant:
BKP
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Subject of this decision:
Construction products and their use for the execution of tube liners with designations "Berolina Liner" and "Berolina HF Liner" for the rehabilitation of underground, damaged wastewater pipes with circular cross-section and nominal sizes DN 150 to DN 1600 and ovoid cross-section in nominal sizes 200 mm/300 mm to 1200 mm/1800 mm

The above-named subject of regulation is herewith granted a national technical approval/approved.
This decision contains 21 pages and 28 appendices.

I GENERAL PROVISIONS

1 This decision verifies usability or applicability of the subject of regulation in line with the state building codes.

2 This decision does not replace the statutory permits, consents and certificates specified for the implementation of construction projects.

3 This decision is issued notwithstanding the rights of third parties, in particular their private industrial property rights.

4 The user of the subject of regulation, notwithstanding further provisions in the “Special provisions” must be provided with copies of this decision. In addition, the user of the subject of regulation must be informed that this decision must be available in the place of use. The authorities involved must also be provided with copies on request.

5 This decision may only be reproduced in full. Publication of excerpts requires the consent of the Deutsches Institut für Bautechnik. Texts and drawings of advertising material may not contradict this decision, translations must contain the note “”Translation of the original German version not checked by the Deutsches Institut für Bautechnik”.

6 This decision is revocable. The provisions can be subsequently added to and changed, especially if new technical knowledge requires this.

7 This decision is based on the information provided by the applicant and the documents submitted. A change to this basis is not covered by this decision and must be disclosed to the Deutsches Institut für Bautechnik immediately.

II SPECIAL PROVISIONS

1 Subject of regulation and area of use or application

This decision applies to the manufacture and use of tube liners with designations "Berolina Liner" (Appendix 1) and "Berolina HF Liner (Appendix 2) using glass fibre reinforced plastic (GRP) tubes for the renovation or rehabilitation of damaged, underground wastewater pipes with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in dimensions from 200 mm/300 mm to 1200 mm/1800 mm in a ratio of approx. W:H = 2:3.
This decision applies to the renovation or rehabilitation of sewers, which are mainly intended to drain domestic wastewater in accordance with DIN 1986-3[1].
The tube liners can be used for the renovation or rehabilitation of wastewater pipes made of concrete, masonry, reinforced concrete, steel (not pressurised pipes), vitrified clay, asbestos-free fibre cement, GRP, PVC-U, PE-HD and cast iron, provided the cross-section of the wastewater pipe to be rehabilitated meets the requirements and the structural needs.
Damaged wastewater pipes are rehabilitated by inserting and subsequently UV curing a polyester or vinyl resin-impregnated seamless glass fibre tube.
Lateral inlets (service laterals) can either be laid using open construction methods or by means of the repair or rehabilitation method, for which current national technical approvals with the corresponding construction technique permits exist.

2 Provisions Concerning the Construction Products

2.1 Properties and composition

Where applicable, the tube liners named in section 1 meet the requirements of EN ISO 11296-4[2], they have the specific properties and compositions named in the following.

2.1.1 Materials of the tube liner components in the "M" state

2.1.1.1 Glass fibre tube materials

The materials used for the outer styrene-tight and UV-protected PE/PA/PE composite foil (film) with a minimum PA thickness of 40 µm (-5 µm + 10 µm) and for the inner multi-layer foil must correspond to the recipe details deposited with the Deutsches Institut für Bautechnik.
Only resins and hardener components corresponding to the recipe details deposited with the Deutsches Institut für Bautechnik may be used to impregnate the glass fibre tubes.
Only unsaturated polyester resins (UP resins to EN 13121-1[3], table 2, group 4 Iso-Npg and Ortho-Npg) of the type 1140 to table 3 or vinyl ester resins (VE resins) of the type 1310 to table 4 of DIN 16946-2[4] may be used.

1	DIN 1986-3	Drainage systems on private ground — Part 3: Specifications for service and maintenance; Issued: 2004-11
2	EN ISO 11296-4	Plastic 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; Issued: 2011-07
3	EN 13121-1	GRP tanks and vessels for use above ground — Part 1: Composite materials; Chemical resistance; German version DIN EN 13121-1:2003; issued: 2003-10
4	DIN 16946-2	Curing casting resins, types; Issued: 1989-03

The polyester and vinyl resins must conform to the recipes and IR spectra deposited with the Deutsches Institut für Bautechnik. The applicant of this decision must also deposit the IR spectra with the external monitoring body.
Only corrosion-resistant glass fibres, e.g. E-CR glass fibres in the form of multiple arranged fabric and/or rovings as well as mats and/or multi-axial rovings, which conform to the requirements of EN 14020-1[5], EN 14020-2[6] and EN 14020-3[7] may be used.
Only polyester non-wovens (PES non-wovens) corresponding to the recipe details deposited with the Deutsches Institut für Bautechnik can be used for reinforcement of the resin-impregnated inner layer facing the wastewater.

2.1.1.2 Materials for manhole joints - swelling tape
Only extruded profiles, consisting of a chloroprene (CR/SBR) rubber and water-absorbing resin may be used for the swelling tape (auxiliary material, Appendix 20) in the area of the manhole jointing of the tube liner. When stored in water, the swelling tapes must have a volume increase of at least 100 % after 72 h.
Compliance of the swelling tapes with the geometric requirements (cross-section shape and dimensions) must be checked visually and by random re-measurement as part of the incoming inspection.

2.1.2 Environmental compatibility

The construction products meet the requirements of the "principles set out in the assessment of the effects of construction products on the soil and groundwater" ("Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser" (Version: 2011, Texts of the Deutsches Institut für Bautechnik). This statement only applies to compliance with the special provisions of this decision.

The permit proviso, particularly in water protection zones, of the competent water authority remains unaffected.

2.2 Production, packaging, transport, storage and labelling

2.2.1 Factory production of the GRP tube liner

The reaction resin is mixed with the additives by static mixers in the feed lines. The metering according to the recipe must be carried out by means of process controlled feed pumps. Compliance with the recipe must be monitored by means of flow measurement and continuous weight reduction in the container connected to the metering unit and must be recorded for each batch.
The glass fibre sheets and foils with properties according to section 2.1.1.1 purchased from suppliers as reel goods must be continuously unwound over low-vibration and level-controlling rolls and fed onto a diameter-specific system. Deflection clips adjusted to the tube liner diameter ensure the correct positioning and alignment of the sheets. The glass fibre sheets must be joined on the system, in compliance with the multi-layer wall construction according to section 3.1.2.1.1 so that at least the wall thicknesses given in Appendices 2 and 3 (circular and ovoid cross-sections) are produced. When joining, ensure that the individual complexes overlap by approx. 10 %. The glass fibre tube is then welded in an outer foil according to section 2.1.1.1 so that a closed tube is produced. The inner foil with the textile glass folded around it must be pulled in together in advance in the production drawing in. A pulling thread/tape must be unwound along the length of the inner foil during production. In the vertical initial draw the closed tube must be impregnated with the mixed resin.

5	EN 14020-1	Reinforcements – Specification for textile glass rovings — Part 1: Designation; German version DIN EN 14020-1:2002; issued: 2003-03
6	EN 14020-2	Reinforcements - Specification for textile glass rovings — Part 2: Methods of test and general requirements; German version DIN EN 14020-2:2002; issued: 2003-03
7	EN 14020-3	Reinforcements - Specification for textile glass rovings — Part 3: Specific requirements; German version DIN EN 14020-3:2002; issued: 2003-03

To prevent resin from escaping, the ends of the tube liner must be sealed with foils and adhesive tapes before it is packed.
Immediately after impregnation, the tube liners fitted with a styrene-tight foil must be placed in layers in transport packaging depending on the tube diameter and flat width. Ensure that intermediate packaging layers are used to spread the weight of the tube liner.
The relevant accident prevention and occupational health regulations must be complied with for factory production of the glass fibre tubes and the resin impregnation. In particular the technical regulations for hazardous materials, limit values in air (TRGS 900[8] "Grenzwerte in der Luft") must be complied with regarding styrene. Ensure that suitable measures are taken (e.g. extraction equipment) to ensure the styrene limits are not exceeded.
Comply with the relevant accident prevention regulations and the implementing regulations of the law on hazardous substances (Gefahrstoff-VO) when handling the impregnated hoses.

2.2.2 Packaging, transport, storage

The resin delivered to the applicant's manufacturing plant for the factory production of tube liners can be stored in suitable storage tanks, in temperature-controlled storage rooms with a monitored temperature range of +5 °C to approx. +30 °C.
The GRP liners produced can be stored in the light and styrene-proof foils in the transport packaging for approx. six months at a temperature of +5 °C to +30 °C. The transport packaging must be protected against direct sunlight and heat sources.
The relevant accident prevention regulations must be complied with during storage and transport.

2.2.3 Labelling

The transport containers of the GRP liners are to be labelled with the German compliance mark (Ü mark) according to the compliance mark regulations of the federal states (including the decision number Z-42.3-336). The labelling may only be carried out if the requirements according to section 2.3 are fulfilled.
The manufacturer must include the hazard symbols and H and P statements on the containers, packaging and package insert or on the delivery note in accordance with the German Hazardous Substances Ordinance and EU Regulation No. 1907/2006 (REACH) as well as the respective current version of the CLP Regulation (EC) 1272/2008[9]. The packagings must be marked according to the current versions of the ADR[10] rules.
In addition, the following information must be given:

— Nominal size
— Wall thickness
— Tube length
— Date of resin impregnation
— Production site (place where resin impregnated)

8	TRGS 900	Technische Regeln für Gefahrstoffe - Grenzwerte der Luft am Arbeitsplatz "Luftgrenzwerte" (Limit values for air in the workplace); Issued: 23/04/2021
9	1272/2008	Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures
10	ADR	European agreement concerning the international transport of dangerous goods by road (Accord européen relatif au transport international des marchandises dangereuses par route)

- Batch number
- Storage temperature range
- H and P statements in accordance with the hazardous substances regulation
- Note on light sensitivity

2.3 Confirmation of compliance

2.3.1 General information

Compliance of the construction products with the provisions of the national technical approval covered by this decision must be confirmed for each manufacturing plant with a declaration of compliance on the basis of the factory production control and a compliance certificate of a recognised certification body as well as regular external monitoring by a recognised monitoring body, including initial testing of the construction products according to the following provisions.
The manufacturer of the construction products must involve a recognised certification body and a recognised monitoring body for the issue of the compliance certificate and the external monitoring including the product tests to be performed for the certificate and tests.
The manufacturer must submit the declaration of compliance by labelling the construction products with the compliance mark (Ü mark) with reference to the intended use.
The certification body must give the Deutsches Institut für Bautechnik a copy of the compliance certificate it has issued, for information purposes.
The Deutsches Institut für Bautechnik must also be given a copy of the initial test report for information purposes.

2.3.2 Factory production control

Factory production control must be set up and carried out in each manufacturing plant. Factory production control is the term used to describe the continuous production monitoring to be carried out by the manufacturer, with which they ensure that the construction products manufactured by them conform to the provisions of this national technical approval covered by this decision.
The factory production control should at least include the measures listed in the following:

1. Description of and checking of the starting material

   Tube liner materials:
   With each delivery of the components: protective foils, glass fibres, polyester non-woven and resins, the applicant must convince themselves that the properties required according to section 2.1.1 are complied with. To this end, the applicant must ensure that the respective suppliers submit to them appropriate type 2.2 test reports based on EN 10204[11].

11 EN 10204 Metallic products - Types of inspection documents; German version DIN EN 10204:2004; issued: 2005-01

The following properties must be randomly checked as part of the incoming inspection:
Properties of the resin:
- Viscosity and change in thickening at the rheometer
- Curing parameters, time and reactivity
- IR spectroscopy

Properties of the glass fibres:
- Mass per unit area
- Width
- Thickness

In addition, the UV permeability of the multi-layer composite foils must be tested randomly.
- UV permeability of the inner protective foil
- Mass per unit area
- Width
- Thickness

2. Checks and tests to be performed during production:

The following parameters are to be monitored and recorded during production of the glass fibre tube and the resin impregnation:
- Feed speed
- Compliance with the recipe (flow measurement of the resin and reduction in weight of the additives)
- Uniformity of the resin impregnation
- Welding parameters (including welding temperature and uniformity of the welded joints of the protective foils)
- Tube width and thickness
- Tube length
- Checking optical brightening agents in the polyester nonwoven
- Batch number

3. Verifications and tests to be carried out on the impregnated glass fibre tubes and cured test pieces:

a) Tests on the resin-impregnated glass fibre tubes:
The widths of the resin-impregnated, not yet inflated tube liners given in the following table 1 (circular cross-sections) and table 2 (ovoid cross-sections) must be checked.

Table 1: "Tube liner widths of circular cross-sections (resin impregnated, not inflated) for the "Berolina Liner" and the "Berolina HF Liner"

Nominal size DN	Average tube liner width in mm (+25 mm -15 mm)	Nominal size DN	Average tube liner width in mm (+25 mm -15 mm)
150	222	675	1,015
190	290	700	1,033
200	290	750	1,120
225	315	800	1,160
250	365	883	1,320
300	450	900	1,340
315	465	950	1,400
350	485	1,000	1,480
375	538	1,050	1,570
400	580	1,100	1,675
450	650	1,150	1,765
480	700	1,200	1830
500	730	1,250	1,900
525	745	1,260	1,920
550	790	1,300	1,950
580	800	1,400	2,160
600	890	1,500	2260
631	920	1,520	2265
650	990	1,600	2390

Table 2: "Tuber liner widths of ovoid cross-sections (resin impregnated, not inflated) for the "Berolina Liner" and the "Berolina HF Liner"

Width/height mm/mm	Average tube liner width in mm (+25 mm -15 mm)	Width/height mm/mm	Average tube liner width in mm (+25 mm -15 mm)
200 / 300	365	700 / 1050	1,320
199 / 375	370	750 / 1125	1,400
250 / 375	470	800 / 1200	1,480
300 / 475	538	840 / 1260	1,570
350 / 525	650	900 / 1350	1,765
400 / 600	730	1000 / 1500	1,920
500 / 750	920	1100 / 1650	2,160
600 / 900	1,120	1200 / 1800	2265

b) Tests on cured test pieces for production control:
Within the scope of the factory production control, regular test specimens must be taken and tested according to section 3.2.4 for random checking of the liner quality. It is necessary to ensure that this test specimen is not exposed to uncontrolled UV radiation. The test specimen must be inflated to the respective nominal size in the applicant's laboratory, under the same criteria as those described in sections 3.2.3.8 to 3.2.3.11 (feed speed according to Appendices 17 and 18), by applying an internal pressure of at least 0.02 bar and cured using the UV lamps named in section 3.2.3.3 and in appendices 7 to 9 and 18.

Compliance with the labelling information according to section 2.2.3 must be checked within the scope of the factory production control.
The results of the factory production control must be recorded and evaluated. The records must contain the following minimum information:

— Designation (name) of the construction product or the starting materials and components,
— Type of control or test,
— Date of manufacture and testing of the construction products or the starting materials or components,
— Results of the controls and tests and, if applicable, comparison with the requirements,
— Signature of the persons responsible for the factory production control.

The records are to be kept for at least five years and must be presented to the inspection body engaged for the external monitoring. They must be submitted to the Deutsches Institut für Bautechnik and the responsible highest building control authority.
If the test results are inadequate, the manufacturer must immediately take the necessary measures to correct the defect. Construction products which do not fulfil the requirements must be handled (quarantined) so that they cannot be mixed up with conforming products. Following correction of the defect – insofar as it is technically possible and necessary to verify the defects correction – the relevant test must be repeated immediately.

2.3.3 External monitoring

In each manufacturing plant, the plant and the factory production control must be checked regularly by external monitoring, however at least once every half-year.
Initial testing of the construction products must be carried out as part of the external monitoring.
The factory production control must be checked with random tests as part of the external monitoring. The requirements of sections 2.1.1.1 and 2.2.3 must be checked.
The manufacturing requirements according to section 2.2.1 must be randomly checked.
The tests carried out on cured test specimens within the scope of the factory production control must be randomly checked as part of the external monitoring. This also includes checking the curing behaviour, the storage stability and the weight per unit area after curing, as well as the IR spectroscopies. The determination of the feed speeds is to be checked for plausibility.
The sampling and tests are the responsibility of the respective recognized monitoring body. The type 2.2 test reports based on EN 10204[11] must also be checked during the external monitoring.
The results of the certification and external monitoring must be kept for at least five years. On request the certification body and/or monitoring body must submit them to the Deutsches Institut für Bautechnik and the responsible highest building control authority.

3 Provisions for Use of the Subject of Regulation

3.1 Planning and design

3.1.1 Planning

The information regarding the necessary sewer or pipe data must be checked, e.g. pipe routing, depth, location of the lateral inlets, manhole depths, groundwater, pipe connections, hydraulic conditions, inspection openings, cleaning intervals. Existing video recordings must be evaluated based on their application. The correctness of the information must be checked on site. The condition of the existing wastewater pipe for plot drainage must be checked to see whether or not the rehabilitation method can be used.

The hydraulic efficiency of the wastewater pipes/sewers must not be impaired by introducing a liner. Appropriate proof is to be provided if necessary.

3.1.2 Design

3.1.2.1 Tube liner in "I" state

3.1.2.1.1 Wall thickness and wall build-up

After the pulling in and curing, the "Berolina Liner" must have a wall build-up of at least four layers (Appendix 1) and the "Berolina HF Liner" a wall build-up of at least six layers (Appendix 2) made of textile glass, which are arranged under the external multi-layer composite foil. The layers consist of textile glass fabric and/or textile glass rovings as well as textile glass mats, which are stitched together to form complexes or multi-axial rovings. Inside, on the side facing the wastewater, the "Berolina Liner" must have a final layer of polyester nonwoven as a wear layer on the inner textile glass mat and an inner multi-layer composite foil (installation foil), which is removed after the GRP tube has cured. The nominal size and stiffness-related wall thicknesses are determined by the number and combinations of multiple complexes/multi-axial rovings.

The wall thickness of the respective cured GRP tube liner must be checked by way of a structural consideration according to DWA-A Arbeitsblatt 143-2 [12] (see also section 3.1.2.1.4).

If the host pipe-soil system itself is no longer load-bearing, such wastewater pipes may only be rehabilitated with the “Berolina Liner” and “Berolina HF Liner” wall thicknesses listed in Appendices 3 and 4 and in Appendices 5 and 6 respectively, if the structural loads to be carried by the tube liner are verified by structural calculation according to leaflet DWA-A Arbeitsblatt 143-2[12].

The short-term ring stiffnesses (2-minute values) of the cured GRP tube liner given in Appendices 3 to 6 for circular and ovoid cross-sections (wall thicknesses depending on the short-term ring stiffness SR) must be complied with for the structural calculation.

GRP tube liners with the nominal stiffnesses and wall thicknesses given in Appendices 3 to 6 (circular and ovoid cross-sections) may be used for the rehabilitation of wastewater pipes if the host pipe-soil system alone is load bearing (without support of the surrounding soil). If there are one or several continuous longitudinal cracks in the host pipe, soil investigations, e.g. by way of penetration tests, are required and appropriate verifying calculations must be performed. In the event of infiltrations, the GRP tube liner must be dimensioned with regard to its deformation and buckling behaviour.

In the system that is the subject of this national technical approval, resin-impregnated tube liners which have a minimum wall thickness of 3 mm after installation and curing are used for rehabilitation measures.

12 DWA-A 143-2 Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA) - Arbeitsblatt 143: Rehabilitation of drainage systems outside of buildings —Part 2: Structural calculations for rehabilitation of wastewater pipes and sewers using lining and installation methods; Issued: 2015-07

Tube liners with a nominal stiffness SN ≥500 N/m² to SN ≥630 N/m² with corresponding wall thicknesses are also allowed.
The following relationships apply to the nominal stiffness SN and short-term ring stiffness SR:

For SN:

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

For SR:

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

(SN = nominal stiffness based on DIN 16869-2[13]) (r_m = gravity radius)

3.1.2.1.2 Dimensions of tube liners for ovoid (egg-shaped) cross-sections
The CIPP lining system can also essentially be used to rehabilitate damaged sewers with ovular cross-sections, which conform to the width and height dimensions and corresponding wall thicknesses given in Appendices 3 to 6.

3.1.2.1.3 Physical characteristics of cured glass fibre-resin composite
Cured GRP liners (without multi-layer foil) must have the following properties:

"Berolina Liner"

— Density based on EN ISO 1183-2[14]:	1.5 g/cm³ ± 0.5 g/cm³
— Glass mass per unit area(per mm load-bearing wall thickness):	650 g/m² + 150 g/m²-100 g/m²
— Glass fibre content based on EN ISO 1172[15] (mass-based):	Mean value 46 % ± 8 %
— Circumferential Young's modulus (short-term) based on EN 1228[16]:	10,000 N/mm²
— Young's flexural modulus based on EN ISO 11296-4[2] or EN ISO 178[17]:	8,700 N/mm²
— Flexural stress σ_{fB} based on EN ISO 11296-4[2]or EN ISO 178[17]:	150 N/mm²

"Berolina HF Liner"

— Density based on EN ISO 1183-2[14]:	1.59 g/cm³ ± 0.5 g/cm³
— Glass mass per unit area(per mm load-bearing wall thickness):	900 g/m² + 150 g/m²-100 g/m²
— Glass fibre content based on EN ISO 1172[15] (mass-based):	Mean value 53 % ± 8 %
— Circumferential Young's modulus (short-term) based on EN 1228[16]:	17,000 N/mm²
— Young's flexural modulus based on EN ISO 11296-4[2] or EN ISO 178[17]:	17,000 N/mm²
— Flexural stress σ_{fB} based on EN ISO 11296-4[2]or EN ISO 178[17]:	280 N/mm²

13	DIN 16869-2	Centrifugally cast filled glass fibre reinforced unsaturated polyester resin (UP-GF) pipes - Part 2: General quality requirements, testing; Issued: 1995-12
14	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 DIN EN ISO 1183-2:2004; Issued: 2004-10
15	EN ISO 1172	Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods (ISO 1172:1996); German version DIN EN ISO 1172:1998; Issued: 1998-12
16	EN 1228	Plastics piping systems. Glass-reinforced thermosetting plastics (GRP) pipes. Determination of initial specific ring stiffness; German version DIN EN 1228:1996; Issued:1996-08
17	EN ISO 178	Plastics — Determination of flexural properties (ISO 178:2019); German version DIN EN ISO 178:2019; Issued: 2019-08

3.1.2.1.4 Structural calculation of the cured tube liner

Structural calculations are to be performed to verify the stability of the planned liner for each rehabilitation project according to DWA-A Arbeitsblatt M 143-2[12] of the "Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA)" before the work begins.
The structural calculations must include a factor of safety for the tube liner material of $y_M = 1.35$.
The reduction factor A for determination of the long-term values has been determined based on EN 761[18].
The following values are to be taken into account in the structural calculations:

"Berolina Liner"

— Circumferential Young's modulus, short-term based on EN 1228[16]:	10,000 N/mm²
— Circumferential Young's modulus, long-term:	6,800 N/mm²
— Short-term flexural stress σ_{fB} based on EN ISO 11296-4[2]or EN ISO 178[17]:	150 N/mm²
— Long-term flexural stress σ_{fB}:	105 N/mm²
— Reduction factor A after 10,000 h:	1.45

"Berolina HF Liner"

— Circumferential Young's modulus, short-term based on EN 1228[16]:	17,000 N/mm²
— Circumferential Young's modulus, long-term:	14,200 N/mm²
— Short-term flexural stress σ_{fB} based on EN ISO 11296-4[2]or EN ISO 178[17]:	280 N/mm²
— Long-term flexural stress σ_{fB}:	235 N/mm²
— Reduction factor A after 10,000 h:	1.19

3.2 Execution

3.2.1 General information

Damaged wastewater pipes are rehabilitated by inserting and subsequently UV curing a resin-impregnated seamless glass fibre tube.
To this end, a smooth foil sleeve (slip membrane) marked with PVC or PE stripes, possibly textile-reinforced, is always pulled into the damaged pipe first as an installation aid. The resin-impregnated glass fibre tube with multi-layer composite films on both sides is pulled over this and is inflated by applying compressed air.
A start and end pit (entry and exit manhole) are required for implementation of the "Berolina Liner" or "Berolina HF Liner" CIPP lining system.
Execution of the "Berolina Liner" or "Berolina HF Liner" lining method is possible under the following structural circumstances:

a) From the start to the end point
b) From the start to the end point through one or several intermediate manholes
c) Beginning from the starting point in a sewer pipe with a defined length, without requiring a further manhole opening
d) Lateral connections, beginning from the starting point to the connection point in the main sewer

The starting point and/or end point can be a manhole, an inspection or cleaning opening or an open pipe section.

18 EN 761 Plastics Piping Systems - Glass-Reinforced Thermosetting Plastics (GRP) Pipes - Determination of the Creep Factor Under Dry Conditions; German version DIN EN 761:1994; issued:1994-08

It is also possible to cross several manholes between the respective start and end points, including crossing through manholes with channel deflections of up to 15 degrees.
If folding occurs, this may not be larger than specified in EN ISO 11296-4[2].
Lateral inlets are renewed from the main pipe or sewer by means of robot technology, using push-in bladders (inflatable seals).
Watertight reconnection of lateral inlets can either be laid using open construction methods or by means of the repair or rehabilitation method, for which current national technical approvals with the corresponding construction technique permits exist.
The applicant must provide the contractor with a manual with a description of the individual actions, based on the type of construction (see also section 3.2.3) and must instruct the contractor in how to carry out the rehabilitation method.
The applicant must also ensure that the contractors are adequately familiarized with the method. Adequate technical knowledge of the contractor can also be documented e.g. by a corresponding quality mark issued by the Güteschutz Kanalbau e. V.[19]

3.2.2 Machinery, components and equipment

Minimum machinery, components and equipment required for execution of the rehabilitation method:

— Sewer cleaning equipment
— Sewer inspection equipment (DWA-M 149-2[20])
— Vehicle fitout:
  - GRP tube liner "Berolina Liner" and/or "Berolina HF Liner" in the suitable nominal sizes (Appendices 1 and 2)
  - Nominal size related smooth PE foils
  - UV light chains according to the schematic diagrams in Appendices 4 to 6 (based on nominal size)
  - Electrical cables for transmission of the temperature measurement data
  - Temperature measuring probes
  - Spare UV lamps
  - Intensimeter for the UV radiation measurements
  - If necessary, rotating swivel shackle (to prevent twisting while the liner is pulled in)
  - Sealing plugs (called packers) with compressed air connections (depending on nominal size) DN 150 to DN 1600 or 200 mm / 300 mm to 1200 mm / 1800 mm
  - Compressed air generator
  - Compressed air hoses
  - Air lock, if necessary
  - Cable winch
  - Workshop and equipment room
  - Electricity generator
  - Control unit with monitor and video camera including computer-controlled recording of the curing parameters

19 Güteschutz Kanalbau e. V.; Linzer Str. 21, Bad Honnef, Phone: (02224) 9384-0, Fax: (02224) 9384-84
20 DWA-M 149-2 Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA) - Markblatt 149: Recording and evaluating the condition of drainage systems outside of buildings - Part 2: Coding system for the optical inspection; Issued: 2013-12

- Edge protection on the manhole and between the manhole and sewer
- If necessary, social and sanitary rooms

If electrical equipment, e.g. video cameras (CCTV) is introduced into the pipe to be rehabilitated, it must have properties according to the VDE regulations.

3.2.3 Carrying out the rehabilitation work

3.2.3.1 Preparation measures

Before starting the work, the sewer to be rehabilitated must be cleaned (Appendix 7), so that the damage can be readily seen on the monitor. Any obstructions preventing the pulling in of the tube must be removed (e.g. tree roots, protruding lateral connection pipes, tar, etc.). When removing such obstructions, ensure that this is only done with suitable tools, so that it does not cause any additional damage to the host pipe.

Before pulling in the liner, ensure that the pipe/sewer concerned is not in use; if necessary, insert cut-off plugs (Appendix 10) and divert the wastewater (Appendices 11 and 12).

People may only climb into the manholes of the sewers to be rehabilitated if they have been tested beforehand to ensure there are no explosive gases in the length of sewer. The same also applies to the equipment used for the rehabilitation method, which is to be introduced into the length of sewer.

To this end, the relevant sections of the following standards are to be observed:

— GUV-R 126[21] (previously GUV 17.6)
— DWA-Merkblatt 149-2[20]
— DWA-A 199-1 and DWA-A 199-2[22]

The correctness of the information named in section 3.1.1 must be checked on site. To this end, the section of the pipe to be rehabilitated must be cleaned with the usual jetting equipment so that the damage can be perfectly identified on the monitor during the visual inspection according to leaflet DWA-M 149-2[20].

The relevant accident prevention regulations must also be observed if people climb into the manholes of the sewers to be rehabilitated and in all steps of the rehabilitation process.

The steps required for implementation of the method are to be defined for each rehabilitation project using record forms (Appendix 24).

3.2.3.2 Incoming inspection of the system components on the construction site

The GRP liners, delivered to site in light and styrene-proof packaging, must be checked on site to ensure the markings named in section 2.2.3 exist, and to ensure the transport packaging according to section 2.2.2 is undamaged. Compliance with the storage and transport temperatures in section 2.2.2 must be checked.

21	GUV-R 126	Sicherheitsregeln: Arbeiten in umschlossenen Räumen von abwassertechnischen Anlagen (previously GUV 17.6) (Safety rules for working in confined spaces of wastewater systems); Issued: 2008-09
22	DWA-A 199-1	Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA) - Arbeitsblatt 199: Dienst- und Betriebsanweisung für das Personal von Abwasseranlagen, - Teil 1: Dienstanweisung für das Personal von Abwasseranlagen; (Work instruction and standard operating procedure for the personnel of wastewater installations); Issued: 2011-11
	DWA-A 199-2	Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (DWA) - Arbeitsblatt 199: Dienst- und Betriebsanweisung für das Personal von Abwasseranlagen, - Teil 2: Betriebsanweisung für das Personal von Kanalnetzen und Regenwasserbehandlungsanlagen (standard operating procedure for the personnel of sewer systems and stormwater treatment plants); Issued: 2020-04

3.2.3.3 Checking the UV lamps
Brand-new UV lamps must be tested for the first time after an operating period of approx. 700 hours using a calibrated measuring device and a suitable measurement set-up according to Appendix 22. After this, each lamp is to be checked at intervals of 120 operating hours.

3.2.3.4 Pulling in the smooth slip foil
Before the GRP tube liner delivered to the construction site can be pulled into the damaged wastewater pipe, e.g. a textile-reinforced polyester strip must always be pulled in as an installation aid (Appendix 13). The width of the smooth foil must be chosen so that the width of the liner to be pulled in is covered with the smooth foil. Instead of the smooth foil, the GRP tube liner with integrated PE installation protection foil can be pulled in (Appendices 1 and 2: integrated installation protection (optional)).

3.2.3.5 Inserting sleeves
Before the GRP tube liner is pulled in from the start manhole to the end manhole, a sleeve must be inserted, either in a manhole to be passed through or in the end manhole. This must be a sleeve with an outer diameter corresponding to the inner diameter of the pipe to be rehabilitated. This is intended to simulate the supporting effect of the existing host pipe. After pulling in the GRP tube liner and curing, samples are to be taken in these areas (see section 3.2.4).

3.2.3.6 Pulling in the GRP tube liner
The GRP tube liner must be taken from the transport packaging (Appendix 14) in such a way that it is not damaged. To do this, the pallet of tube liners must be opened on the side on which the yellow "Start" sign is attached. The tube liner must be pulled out there.
A so-called "pull-in head" must be made at the end of the liner, i.e. the liner must be folded lengthwise so that a pull in rope can be fixed onto it (e.g. by means of ratchet straps).
The GRP tube liner must be pulled into the pipe to be rehabilitated via a cable winch, possibly with a pulley at the edge of the start manhole and a deflection bend corresponding to the nominal size of the pipe to be rehabilitated, in compliance with the pull-in forces of the winches named in appendices 27 and 28. At the same time, ensure that the liner is not damaged.
Biologically degradable oil can be applied to the smooth foil to reduce the pulling in forces.
When pulling in the pipe, if necessary, use so-called "rotating swivel shackles" to ensure that the GRP tube liner does not twist about its longitudinal axis.

3.2.3.7 Positioning of sealing tapes (auxiliary materials)
After pulling in the tube liner and before inflating and calibrating the GRP tube, one or two swelling profiled tapes or butyl rubber adhesive tapes must be positioned at approx. 5 cm to 15 cm from the start of the pipe to be rehabilitated. These are to be positioned by hand (Appendices 20 and 23)
The tapes must also be positioned in each manhole passed through and at the end manhole in the same way.
If sealing compounds are used, only sealing compounds for which the national technical approvals with the corresponding construction technique permits are valid may be used.

3.2.3.8 Inflation of the GRP tube liner
After the GRP tube liner has been pulled in the ends of the tube must be sealed using so-called "packers" (Appendix 15). Packers designed as air locks can also be used. The GRP tube liner is to be inflated by applying compressed air. The pressure must be built up as slowly as possible up to maximum 0.02 bar.

3.2.3.9. Inserting the UV light sources
After the GRP tube liner has been inflated, the pressure must be released and the light source related to the nominal size must be fed into the GRP tube liner (Appendix 16). If an air lock is used do not relieve the pressure. In this case the light source must be introduced into the GRP tube liner via the air lock. The pulling cable of the UV light source and the power supply cable must be pulled through the corresponding openings in the packer. When inserting the UV light source in the GRP tube liner, ensure that the inner foil is not damaged.

3.2.3.10 Calibration of the GRP tube liner
After inflating the liner and inserting the UV light source, after waiting for approx. 3 minutes to 5 minutes, the internal pressure must be increased in pressure stages of 0.05 bar to approx. 0.5 bar. After each pressure stage, a waiting period of approx. 3 to 5 minutes should be allowed for. During the calibration, the approx. 10 % overlapping, resin-impregnated glass fibre complexes move, so that form-fit positioning of the tube liner against the host pipe is achieved. In the case of smaller nominal sizes, higher internal pressures may be necessary for complete expansion.

3.2.3.11 Curing the GRP tube liner with light
The light source may only be switched on if there are no longer any people in the start manhole and the UV light source has been completely inserted in the GRP tube liner.
As soon as the light source has been switched on, it must be pulled to the end manhole with a feed speed depending on the nominal size according to the details given in Appendices 17 and 18 or with the contract-related feed speed.
For the feed speeds of the UV light trains not yet named in Appendices 17 and 18, the applicant must determine the feed speeds to be complied with for a specific contract or order depending on the nominal sizes, wall thicknesses and types of resin named in Appendices 17 and 18 and then notify the contractor accordingly.
The necessary measurements must be documented in writing.
If the UV light sources are switched on, ensure that a minimum spacing of 55 mm is maintained between the individual lamps and the inner surface of the liner, regardless of the nominal size.
During the light curing, heat is produced by the reaction of the resin. The resulting temperatures on the surface of the GRP tube liner must not exceed a temperature level of approx. +140 °C.
The temperature level must be continuously checked using temperature measuring probes while the light source is pulled through and the results recorded. If the temperature exceeds the specified level, the air throughput must be increased by opening a valve in the packer at the end manhole and simultaneously maintaining the internal pressure.
The change in pressure during the light curing, the position of the UV light source, the speed of the UV light source, the functional condition of the UV lamps and the air temperature at the surface of the liner are also to be recorded.

3.2.3.12 Removal of the inner foil
After a cooling phase lasting several minutes, the UV light source must be removed from the cured GRP tube liner, after the pressure has been released. The packers must then be removed and then the inner foil is removed

3.2.3.13 Leak test on the GRP tube liner
As an intermediate test, the leak tightness of the cured GRP tube liner can be checked before cutting open the lateral connections and making the manhole joints (Appendices 19 and 25) according to the criteria in EN 1610[23] (see section 3.2.3.18).

23 EN 1610 Construction and testing of drains and sewers; German version
DIN EN 1610:2015; issued: 2015-12

3.2.3.14 Final work

After curing and cooling, air-powered cutting tools must be used to cut off and remove the inner pipe that has been made, in the start and end manhole with approx. 2 cm to 3 cm wide overhang at the respective manhole wall. The top half-shell of the pipe made must be removed in the intermediate manholes, down to the bench in the floor of the manhole.

Any samples necessary for the subsequent tests must be taken from the pipe sections removed (see section 3.2.4).

The cutting work must be carried out in compliance with the relevant accident prevention regulations.

3.2.3.15 Manhole jointing

Manhole joints are to be made watertight using expanding auxiliary tapes (Section 3.2.3.7, Appendix 20), which are to be positioned in the area of the manhole joints before the protective tube (PE or PVC smooth foil) is pulled in.

Both in the respective start and end manhole, and in the intermediate manholes, the overhangs made (see also section 3.2.3.14 — final work) of the cured inner pipe with the end face of the manhole (so-called "mirror") and the cross-overs to the flow channel in the start and end manholes must be made watertight.

In the areas in which expanding tapes (auxiliary tapes) cannot be used for constructional reasons, the water-tight formation of the jointing areas between the tube liner and manhole after curing of the tube liner can also be carried out in the following way:

a) Connecting the tube liner by means of reactive resin compound, for which a current national technical approval exists,
b) Connecting the tube liner by means of mortar systems, for which a current national technical approval exists,
c) GRP laminates for which a current national technical approval exists,
d) Injection with polyurethane (PU) or epoxy (EP) resins for which a current national technical approval exists,
e) Installation of tube liner end sleeves for which a current national technical approval exists.

Ensure proper water-tight design of the changeovers.

3.2.3.16 Restoring lateral inlets

Lateral inlets can either be laid using open construction methods or by means of the repair or rehabilitation method (e.g. Appendix 21), for which current national technical approvals with the corresponding construction technique permits exist.

3.2.3.17 Labelling in the manhole

The following labelling should be attached in the start or end manhole of the rehabilitation work, in a permanent and readily legible position:

— Type of rehabilitation

Name of the sewer line/length of pipe

— Nominal size
— Wall thickness of the tube liner
— Year of rehabilitation

3.2.3.18 Final inspection and leak test

Following completion of the work the rehabilitated length of sewer must be visually inspected. It is necessary to ensure that any material residues have been removed and there are no hydraulically disadvantageous folds. There must be no exposed glass fibres.
After curing the liner, including making the manhole joints and renewing the lateral inlets, the tightness must be tested. This can also be done in sections (Appendix 19 and leak record Appendix 25).
The tightness of the rehabilitated pipes must be tested using water ("W" method) or air ("L" method) to EN 1610[23]. If testing using air, the specifications in
Table 3 of EN 1610[23], LB test method for dry concrete pipes must be observed.
Lateral inlets rehabilitated by means of the top hat technique can also be tested for watertightness separately using suitable inflatable cut-off seals.

3.2.4 Tests on samples taken

3.2.4.1 General

On the construction site, circular rings or segments are to be taken from the cured circular or approximately circular liners for ovular cross-sections. If the sample pieces taken for the named tests are found to be unsuitable, the tests on the properties to be complied with can be carried out on samples taken directly from the cured liner (sample accompanying document Appendix 26).
For liners with ovular cross-sections, the samples must be taken from the area with the largest buckling load, in the area of the cross-section between 3:00 and 5:00 o'clock.
The sampling point of sewers with ovular cross-sections with width/height dimensions of k 600 mm/900 mm must then be re-sealed using hand applied laminate with the same wall thickness.

3.2.4.2 Strength properties

The modulus of elasticity in flexure and the flexural stress σ_{fB} of the sample pieces or circular rings taken must be determined. In these tests, the 2-minute value, the 1-hour value and the 24-hour value of the modulus of elasticity in flexure and the 2-minute value of the bending stress σ_{fB} must be recorded.
In the test it must also be determined whether the creep tendency based on EN ISO 899-2[24] of KN < 16 % is complied with for the "Berolina Liner" and KN 5 10 % for the "Berolina HF Liner" according to the following relationship:

$$K_N = \frac{E_{2min} - E_{1h}}{E_{2min}} \times 100$$

The testing of circular segments must be carried out using the three-point method according to EN ISO 11296-4[2] or EN ISO 178[17] (modulus of elasticity in flexure and flexural stress σ_{fB}).
Curved test rods from the relevant circular cross-section are to be used, which have been taken from the segments in the radial direction with a minimum width of 50 mm. The span width measured between the support points of the sample rod must be taken into account in the testing and calculation of the modulus of elasticity. The flexural stress may not be less than σ_{fB} = 150 N/mm2 for the "Berolina Liner" and 280 N/mm2 for the "Berolina HF Liner".
The short-term values determined for the flexural stress σ_{fB} and the moduli of elasticity (1-minute values) must be equal to or greater than the values given in section 3.1.2.1.4 or section 3.1.2.1.3.
Also, if the resin supplier is changed, a complete circular ring (pipe section) must be taken from the cured tube. Its ring stiffness must be checked. The 2-minute value, the 1-hour value and the 24-hour value of the ring stiffness must be recorded in the test. The ring stiffness is to be tested using the method described in DIN 53769-3[25] or EN 1228[16] including the creep tendency.

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

In addition, the Barcol hardness must be tested on the outside of the test specimen, under the outer foil. This must have a value of at least 40 scale divisions.

3.2.4.3 Water tightness

The water-tightness of the cured GRP tube liner must be carried out by testing test pieces taken from the cured tube liner without inner and external foil coating, based on the criteria in EN 1610[23] (Appendix 25).

The test on test pieces can either be carried out with overpressure or underpressure of 0.5 bar. If underpressure testing is used, the sample must be impinged on one side with water. At an underpressure of 0.5 bar, no water may visibly leak from the side of the sample without water impingement for a test period of 30 minutes.

If testing using overpressure, water pressure of 0.5 bar must be applied for 30 minutes. With this method too, there must be no visible water leaks on the unimpinged side of the sample.

3.2.4.4 Tightness

The density of the samples taken from the cured tube liner must be tested without the PE foil or the fabric-reinforced PVC tube foil and without smooth foil and without foil coating, e.g. to EN ISO 1183-1[14]. The purpose of the test is to determine whether or not the density of the cured GRP tube liner conforms to the density given in section 3.1.2.1.3.

3.2.4.5 Wall thickness and wall build-up

The average and total wall thickness and the wall build-up according to the conditions in section 3.1.2.1.1 must be checked at cut surfaces, e.g. using a light microscope with approx. 10-fold magnification. At the same time, the thickness of the pure resin layer must also be checked. In addition, the average percentage area of any blowholes/voids/shrinkage cavities must be tested to EN ISO 7822[26] (determination of void content).

3.2.4.6 Visual inspection

The surfaces of the cured test specimen must be checked for damage and defects (imperfections). To this end, the percentage area of any blowholes/voids/shrinkage cavities in the outer surface of the liner must be determined to EN ISO 7822[26].

3.2.4.7 Glass fibre content/resin content

The glass fibre content and resin content are to be checked according to the specifications in section 3.1.2.1.3 to EN ISO 1172[15].

3.2.5 Declaration of compliance for the rehabilitation work carried out

Compliance of the completed rehabilitation work with the provisions of the national technical approval covered by this decision must be confirmed by the contractor with a declaration of compliance based on the specifications in tables 3 and 4. Documents concerning the properties of the system components according to section 2.1.1 and the results of the tests according to tables 3 and 4 must be attached to the declaration of compliance.

25	DIN 53769-3	Testing of glass fibre reinforced plastics pipes; determination of initial and long-term ring stiffness; Issued: 1988-11
26	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 DIN EN ISO 7822:1999; Issued: 2000-01

The manager of the rehabilitation project or a qualified representative of the manager must be present on the construction site while the rehabilitation work is being carried out. They must ensure proper completion of the work according to the provisions of section 3.2 and, in particular, carry out or organize the tests according to table 3 and the tests according to table 4. The tests on test pieces according to table 4 are to be carried out by a monitoring body approved by the building control authorities (see list of test, monitoring and certification bodies according to the state building code regulations, (Landesbauordnungen) Part V, No. 9).
Once every half-year a liner of a completed rehabilitation project must be sampled by the previously named monitoring body. They must also check the documentation of the rehabilitation projects tests according to table 3.

Table 3: "Process-accompanying tests"

Subject of the test	Type of requirement	Frequency
Visual inspection of the pipe	according to section 3.2.3.1 and DWA-M 149-2[20]	before each rehabilitation
Visual inspection of the pipe	according to section 3.2.3.18 and DWA-M 149-2[20]	after each rehabilitation
Equipment requirements	according to section 3.2.2	each construction site
Labelling the containers of the rehabilitation components	according to section 2.2.3	
Pulling-in forces and internal pressures on inflating	according to section 3.2.3.8	
Temperature level and speed of the UV light source	according to section 3.2.3.11	
Condition of the UV lamps	according to section 3.2.3.3	
Air and/or water-tightness	according to section 3.2.3.18	

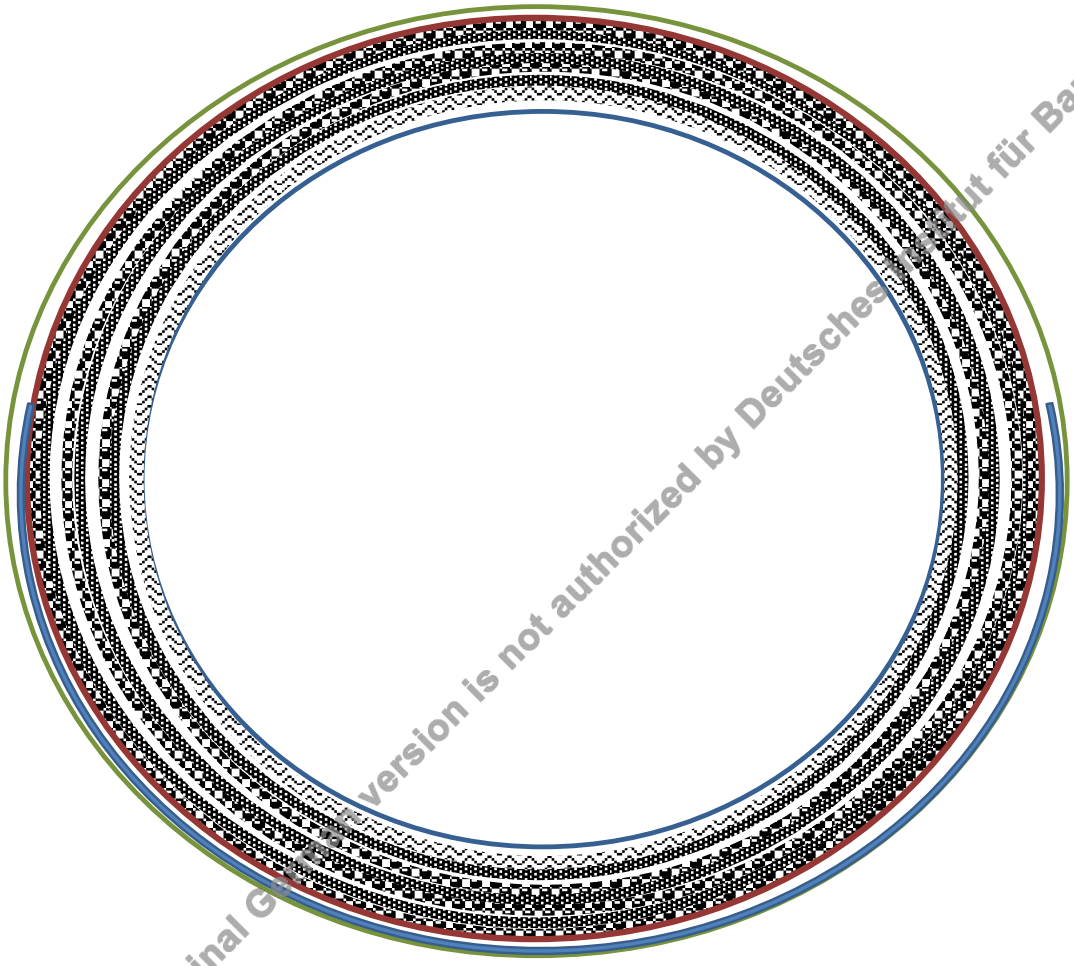
The tests named in table 4 must be organized by the manager of the rehabilitation work or their qualified representative. Samples for the tests named in table 4 must be taken from the cured GRP liners. The test results must be recorded and evaluated; the must be submitted to the Deutsche Institut für Bautechnik on demand. The number and scope of the listed specifications are minimum requirements.

Table 4: "Tests on samples"

Subject of the test	Type of requirement	Frequency
Short-term modulus of elasticity in flexure, short-term flexural stress σ_{fB} and creep tendency at pipe cut-outs or circular rings	according to sections 3.2.4.1 and 3.2.4.2	each construction site, at least every second GRP tube liner
Density and glass content of the sample without smooth foil and without coating foil	according to sections 2.3.2 and 3.1.2.1.3, 3.2.4.4 and 3.2.4.7	
Water-tightness of the sample without smooth foil and without coating foil	according to section 3.2.4.5	
Wall thickness and wall build-up	according to sections 3.1.2.1.1 and 3.2.4.5	
Ring stiffness and creep tendency at pipe sections or cut-outs	according to sections 3.1.2.1.3 and 3.2.4.2	With each change of the resin supplier with declaration of the resins
Resin identity by means of IR spectroscopy	according to section 2.1.1	With each change of the resin supplier with declaration of the resins
Creep tendency at pipe sections or cut-outs	according to section 3.2.4.2	if the values are less than the short-term modulus of elasticity named in section 3.1.2.1.4 and at least 1 x tube liner per half-year

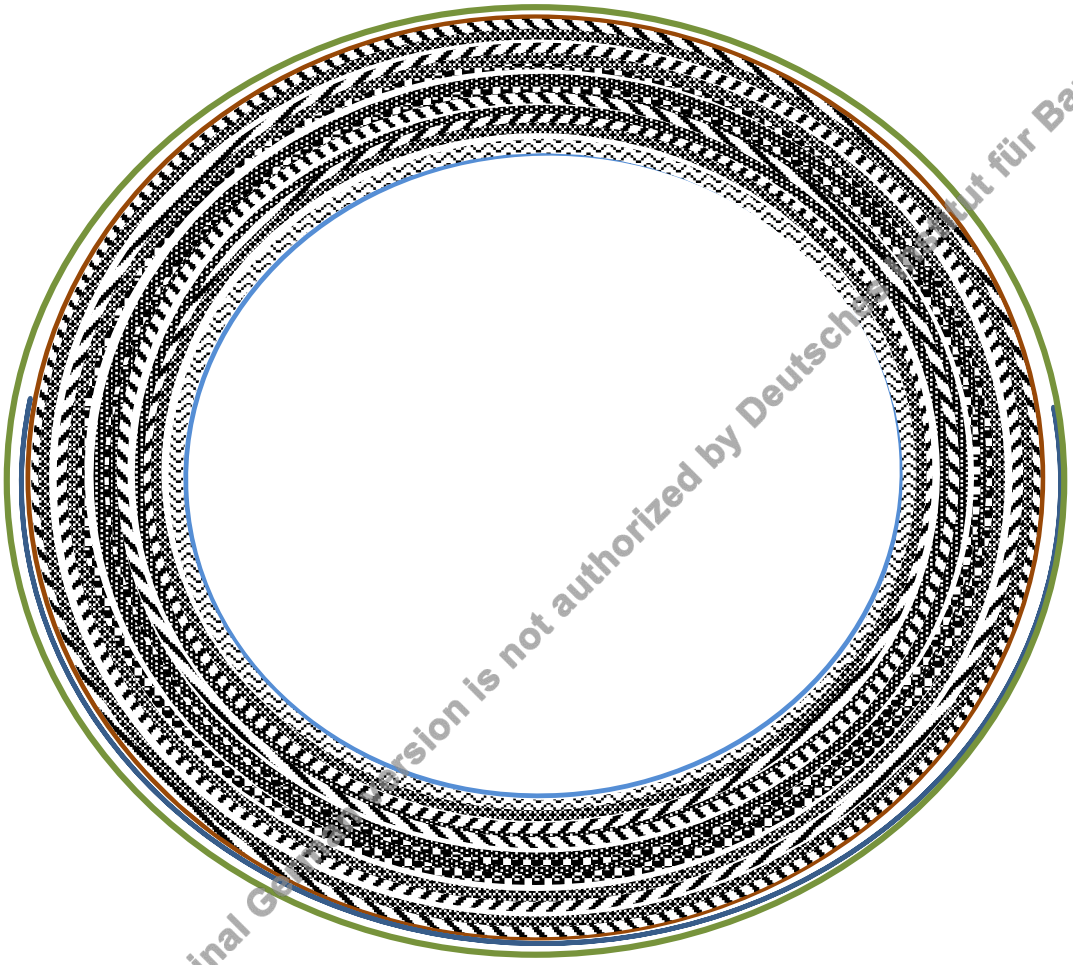
Christina Pritzkow
Head of Department

Authenticated
[Signature]
[Stamp: Deutsches Institut für Bautechnik]



Inner foil
Nonwoven layer as wear / chemical protection layer
Textile glass mat layers
Textile glass fabric layers
Outer foil
integrated installation protection IES (optional)
detachable daylight protection foil (optional)

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (under-ground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 1**
schematic diagram of a Berolina liner wall build-up	



Inner foil
Nonwoven layer as wear / chemical protection layer
Textile glass mat layer
Textile glass fabric layer
Textile glass multiaxial roving layer
Outer foil
integrated installation protection IES (optional)
detachable daylight protection foil (optional)

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (under-ground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 2**
schematic diagram of a Berolina-HF liner wall build-up	

Short term modulus of elasticity **10,000 N/mm²** Berolina liner UP and VE resins

non-load bearing layers: Wear layer 0.5 mm; outer foil 0.3 mm = 0.8 mm (is not taken into consideration in the structural calculations)

Liner thickness	3,5	4,0	4,5	5,0	6,0	7,0	8,0
DN 150	41.057 N/m²	69.053 N/m²	107.840 N/m²	159.362 N/m²	308.754 N/m²		
DN 200	17.085 N/m²	28.660 N/m²	44.643 N/m²	65.799 N/m²	126.810 N/m²	218.284 N/m²	
DN 225	11.945 N/m²	20.020 N/m²	31.158 N/m²	45.884 N/m²	88.275 N/m²	151.685 N/m²	240.842 N/m²
DN 250	8.676 N/m²	14.532 N/m²	22.601 N/m²	33.259 N/m²	63.898 N/m²	109.643 N/m²	173.844 N/m²
DN 300	4.994 N/m²	8.355 N/m²	12.981 N/m²	19.084 N/m²	36.588 N/m²	62.651 N/m²	99.127 N/m²
DN 315	4.308 N/m²	7.207 N/m²	11.194 N/m²	16.452 N/m²	31.526 N/m²	53.958 N/m²	85.330 N/m²
DN 350	3.132 N/m²	5.237 N/m²	8.131 N/m²	11.945 N/m²	22.867 N/m²	39.099 N/m²	61.771 N/m²
DN 375	2.543 N/m²	4.250 N/m²	6.597 N/m²	9.688 N/m²	18.536 N/m²	31.675 N/m²	50.012 N/m²
DN 400	2.092 N/m²	3.497 N/m²	5.426 N/m²	7.966 N/m²	15.233 N/m²	26.017 N/m²	41.057 N/m²
DN 450		2.449 N/m²	3.799 N/m²	5.575 N/m²	10.652 N/m²	18.177 N/m²	28.660 N/m²
DN 480		2.015 N/m²	3.125 N/m²	4.585 N/m²	8.758 N/m²	14.938 N/m²	23.544 N/m²
DN 500		1.782 N/m²	2.762 N/m²	4.053 N/m²	7.738 N/m²	13.196 N/m²	20.792 N/m²
DN 550		1.336 N/m²	2.071 N/m²	3.038 N/m²	5.797 N/m²	9.880 N/m²	15.559 N/m²
DN 580		1.138 N/m²	1.764 N/m²	2.587 N/m²	4.936 N/m²	4.936 N/m²	13.240 N/m²
DN 600		1.028 N/m²	1.593 N/m²	2.335 N/m²	4.455 N/m²	7.589 N/m²	11.945 N/m²
DN 650			1.251 N/m²	1.834 N/m²	3.497 N/m²	5.954 N/m²	9.369 N/m²
DN 675			1.116 N/m²	1.636 N/m²	3.119 N/m²	5.311 N/m²	8.355 N/m²
DN 700			1.000 N/m²	1.466 N/m²	2.795 N/m²	4.758 N/m²	7.483 N/m²
DN 750			812 N/m²	1.191 N/m²	2.269 N/m²	3.861 N/m²	6.071 N/m²
DN 800			669 N/m²	980 N/m²	1.867 N/m²	3.177 N/m²	4.994 N/m²
DN 850					1.555 N/m²	2.645 N/m²	4.157 N/m²
DN 883					1.386 N/m²	2.357 N/m²	3.704 N/m²
DN 900					1.308 N/m²	2.225 N/m²	3.497 N/m²
DN 1000					952 N/m²	1.619 N/m²	2.543 N/m²
DN 1050					822 N/m²	1.397 N/m²	2.194 N/m²
DN 1100						1.214 N/m²	1.907 N/m²
DN 1136						1.102 N/m²	1.730 N/m²
DN 1170						1.008 N/m²	1.583 N/m²
DN 1200						934 N/m²	1.466 N/m²
DN 1250						826 N/m²	1.296 N/m²
DN 1300						734 N/m²	1.152 N/m²
DN 1400						587 N/m²	921 N/m²
DN 1500						477 N/m²	748 N/m²
DN 1600						392 N/m²	616 N/m²
oid cross-sections							
200/300	2.877 N/m²	4.809 N/m²	7.466 N/m²	10.966 N/m²	20.988 N/m²	35.877 N/m²	56.666 N/m²
250/375	1.466 N/m²	2.499 N/m²	3.799 N/m²	5.575 N/m²	10.652 N/m²	18.177 N/m²	28.660 N/m²
300/450	846 N/m²	1.412 N/m²	2.189 N/m²	3.211 N/m²	6.128 N/m²	10.446 N/m²	16.452 N/m²
350/525		887 N/m²	1.375 N/m²	2.015 N/m²	3.843 N/m²	6.546 N/m²	10.301 N/m²
400/600		593 N/m²	919 N/m²	1.347 N/m²	2.567 N/m²	4.369 N/m²	6.871 N/m²
500/750			469 N/m²	687 N/m²	1.308 N/m²	2.225 N/m²	3.497 N/m²
600/900			271 N/m²	397 N/m²	755 N/m²	1.283 N/m²	2.015 N/m²
700/1050					474 N/m²	806 N/m²	1.265 N/m²
800/1200					317 N/m²	539 N/m²	846 N/m²
900/1350						378 N/m²	593 N/m²
1000/1500						275 N/m²	432 N/m²
1200/1800						159 N/m²	249 N/m²

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 3

Berolina-Liner Table of short-term ring stiffness (SR) Part 1

Short term modulus of elasticity **10,000 N/mm²** — Berolina liner UP and VE resins

non-load bearing layers: Wear layer 0.5 mm; outer foil 0.3 mm = 0.8 mm (is not taken into consideration in the structural calculations)

Liner thickn	9,0	10,0	11,0	12,0	13,0	14,0	15,0	16,0
DN 150								
DN 200								
DN 225								
DN 250								
DN 300	147.943 N/m²							
DN 315	127.287 N/m²							
DN 350	92.052 N/m²							
DN 375	74.484 N/m²							
DN 400	61.116 N/m²	86.978 N/m²	119,449 N/m²	159,362 N/m²				
DN 450	42.626 N/m²	60.610 N/m²	83.166 N/m²	110,857 N/m²				
DN 480	35.001 N/m²	49.747 N/m²	68.229 N/m²	90,908 N/m²				
DN 500	30.902 N/m²	43.910 N/m²	60.208 N/m²	80,199 N/m²				
DN 550	23.112 N/m²	32.822 N/m²	44.979 N/m²	59,880 N/m²				
DN 580	19.662 N/m²	27.914 N/m²	38.242 N/m²	50.896 N/m²				
DN 600	17.735 N/m²	25.174 N/m²	34.482 N/m²	45.884 N/m²	59.607 N/m²	75.886 N/m²	94.957 N/m²	117,062 N/m²
DN 650	13.904 N/m²	19.729 N/m²	27.013 N/m²	36.931 N/m²	46.659 N/m²	59.377 N/m²	74.270 N/m²	91.523 N/m²
DN 675	12.398 N/m²	17.589 N/m²	24.079 N/m²	32.022 N/m²	41.576 N/m²	52.899 N/m²	66.155 N/m²	81.508 N/m²
DN 700	11.102 N/m²	15.748 N/m²	21.555 N/m²	28.660 N/m²	37.205 N/m²	47.330 N/m²	59.181 N/m²	72.903 N/m²
DN 750	9.005 N/m²	12.769 N/m²	17.473 N/m²	23.226 N/m²	30.142 N/m²	38.334 N/m²	47.918 N/m²	59.011 N/m²
DN 800	7.405 N/m²	10.497 N/m²	14.360 N/m²	19.084 N/m²	24.759 N/m²	31.480 N/m²	39.340 N/m²	48.435 N/m²
DN 850	6.162 N/m²	8.734 N/m²	11.945 N/m²	15.870 N/m²	20.586 N/m²	26.168 N/m²	32.694 N/m²	40.243 N/m²
DN 883	5.491 N/m²	7.781 N/m²	10.641 N/m²	14.136 N/m²	18.333 N/m²	23.301 N/m²	29.108 N/m²	35.825 N/m²
DN 900	5.183 N/m²	7.344 N/m²	10.042 N/m²	13.340 N/m²	17.300 N/m²	21.986 N/m²	27.464 N/m²	33.799 N/m²
DN 1000	3.768 N/m²	5.337 N/m²	7.296 N/m²	9.688 N/m²	12.560 N/m²	15.957 N/m²	19.925 N/m²	24.513 N/m²
DN 1050	3.251 N/m²	4.604 N/m²	6.293 N/m²	8.355 N/m²	10.830 N/m²	13.758 N/m²	17.177 N/m²	21.129 N/m²
DN 1100	2.824 N/m²	4.000 N/m²	5.466 N/m²	7.256 N/m²	9.405 N/m²	11.971 N/m²	14.912 N/m²	18.340 N/m²
DN 1136	2.562 N/m²	3.629 N/m²	4.958 N/m²	6.582 N/m²	8.529 N/m²	10.832 N/m²	13.522 N/m²	16.629 N/m²
DN 1170	2.344 N/m²	3.319 N/m²	4.535 N/m²	6.019 N/m²	7.800 N/m²	9.905 N/m²	12.363 N/m²	15.203 N/m²
DN 1200	2.171 N/m²	3.074 N/m²	4.200 N/m²	5.575 N/m²	7.224 N/m²	9.173 N/m²	11.448 N/m²	14.077 N/m²
DN 1250	1.920 N/m²	2.717 N/m²	3.712 N/m²	4.927 N/m²	6.383 N/m²	8.105 N/m²	10.114 N/m²	12.435 N/m²
DN 1300	1.705 N/m²	2.414 N/m²	3.297 N/m²	4.375 N/m²	5.668 N/m²	7.196 N/m²	8.980 N/m²	11.039 N/m²
DN 1400	1.363 N/m²	1.930 N/m²	2.635 N/m²	3.497 N/m²	4.529 N/m²	5.749 N/m²	7.173 N/m²	8.816 N/m²
DN 1500	1.107 N/m²	1.567 N/m²	2.140 N/m²	2.838 N/m²	3.676 N/m²	4.665 N/m²	5.820 N/m²	7.152 N/m²
DN 1600	911 N/m²	1.290 N/m²	1.761 N/m²	2.335 N/m²	3.024 N/m²	3.838 N/m²	4.787 N/m²	5.882 N/m²
d cross-sections								
200/300								
250/375	42.626 N/m²							
300/450	24.440 N/m²							
350/525	15.290 N/m²	21.698 N/m²	29.714 N/m²	39.529 N/m²				
400/600	10.192 N/m²	14.455 N/m²	19.783 N/m²	26.302 N/m²				
500/750	5.183 N/m²	7.344 N/m²	10.042 N/m²	13.340 N/m²	17.300 N/m²	21.986 N/m²	27.464 N/m²	33.799 N/m²
600/900	2.985 N/m²	4.228 N/m²	5.778 N/m²	7.671 N/m²	9.943 N/m²	12.629 N/m²	15.767 N/m²	19.393 N/m²
700/1050	1.874 N/m²	2.653 N/m²	3.624 N/m²	4.809 N/m²	6.231 N/m²	7.911 N/m²	9.873 N/m²	12.138 N/m²
800/1200	1.252 N/m²	1.772 N/m²	2.420 N/m²	3.211 N/m²	4.159 N/m²	5.279 N/m²	6.586 N/m²	8.094 N/m²
900/1350	878 N/m²	1.242 N/m²	1.696 N/m²	2.249 N/m²	2.913 N/m²	3.696 N/m²	4.610 N/m²	5.665 N/m²
1000/1500	639 N/m²	904 N/m²	1.234 N/m²	1.636 N/m²	2.119 N/m²	2.688 N/m²	3.352 N/m²	4.118 N/m²
1200/1800	369 N/m²	522 N/m²	712 N/m²	944 N/m²	1.222 N/m²	1.550 N/m²	1.932 N/m²	2.373 N/m²

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 4

Berolina-Liner Table of short-term ring stiffness (SR) Part 2

Short term modulus of elasticity **17,000 N/mm²** Berolina-HF liner UP and VE resins

non-load bearing layers: Wear layer 0.5 mm; outer foil 0.3 mm = 0.8 mm (is not taken into consideration in the structural calculations)

Liner thickness	3,5	4,0	4,5	5,0	6,0	7,0	8,0
DN 150	75.168 N/m²	126.422 N/m²	197.497 N/m²	291.898 N/m²			
DN 200	30.922 N/m²	51.876 N/m²	80.812 N/m²	119.118 N/m²	229.609 N/m²	395.308 N/m²	
DN 225	21.537 N/m²	36.099 N/m²	56.186 N/m²	82.745 N/m²	159.214 N/m²	273.619 N/m²	
DN 250	15.596 N/m²	26.123 N/m²	40.630 N/m²	59.795 N/m²	114.891 N/m²	197.166 N/m²	312.649 N/m²
DN 300	8.936 N/m²	14.952 N/m²	23.231 N/m²	34.153 N/m²	65.484 N/m²	112.140 N/m²	177.442 N/m²
DN 315	7.701 N/m²	12.882 N/m²	20.010 N/m²	29.411 N/m²	56.363 N/m²	96.473 N/m²	152.575 N/m²
DN 350	5.587 N/m²	9.342 N/m²	14.504 N/m²	21.308 N/m²	40.794 N/m²	69.754 N/m²	110.207 N/m²
DN 375	4.530 N/m²	7.572 N/m²	11.752 N/m²	17.260 N/m²	33.024 N/m²	56.434 N/m²	89.110 N/m²
DN 400	3.723 N/m²	6.222 N/m²	9.655 N/m²	14.175 N/m²	27.109 N/m²	46.301 N/m²	73.071 N/m²
DN 450		4.350 N/m²	6.747 N/m²	9.902 N/m²	18.920 N/m²	32.288 N/m²	50.911 N/m²
DN 480		3.576 N/m²	5.546 N/m²	8.137 N/m²	15.541 N/m²	26.509 N/m²	41.782 N/m²
DN 500		3.160 N/m²	4.899 N/m²	7.187 N/m²	13.724 N/m²	23.404 N/m²	36.878 N/m²
DN 550			3.669 N/m²	5.381 N/m²	10.269 N/m²	17.502 N/m²	27.562 N/m²
DN 580			3.123 N/m²	4.580 N/m²	8.738 N/m²	14.888 N/m²	23.440 N/m²
DN 600			2.818 N/m²	4.133 N/m²	7.883 N/m²	13.429 N/m²	21.138 N/m²
DN 650			2.212 N/m²	3.242 N/m²	6.182 N/m²	10.528 N/m²	16.565 N/m²
DN 675			1.973 N/m²	2.892 N/m²	5.513 N/m²	9.387 N/m²	14.767 N/m²
DN 700			1.767 N/m²	2.590 N/m²	4.938 N/m²	8.405 N/m²	13.221 N/m²
DN 750			1.434 N/m²	2.102 N/m²	4.006 N/m²	6.817 N/m²	10.720 N/m²
DN 800			1.180 N/m²	1.729 N/m²	3.295 N/m²	5.605 N/m²	8.812 N/m²
DN 850					2.742 N/m²	4.664 N/m²	7.331 N/m²
DN 883						4.156 N/m²	6.531 N/m²
DN 900						3.923 N/m²	6.164 N/m²
DN 1000						2.852 N/m²	4.480 N/m²
DN 1050						2.460 N/m²	3.864 N/m²
DN 1100						2.138 N/m²	3.357 N/m²
DN 1136						1.939 N/m²	3.045 N/m²
DN 1170						1.774 N/m²	2.785 N/m²
DN 1200						1.643 N/m²	2.580 N/m²
DN 1250							2.281 N/m²
DN 1300							2.026 N/m²
DN 1400							
DN 1500							
DN 1600							
oid cross-sections							
200/300	5.128 N/m²	8.574 N/m²	13.310 N/m²	19.551 N/m²	37.421 N/m²	63.970 N/m²	101.044 N/m²
250/375	2.604 N/m²	4.350 N/m²	6.747 N/m²	9.902 N/m²	18.920 N/m²	32.288 N/m²	50.911 N/m²
300/450	1.499 N/m²	2.502 N/m²	3.879 N/m²	5.689 N/m²	10.858 N/m²	18.508 N/m²	29.150 N/m²
350/525		1.569 N/m²	2.431 N/m²	3.564 N/m²	6.797 N/m²	11.577 N/m²	18.218 N/m²
400/600		1.048 N/m²	1.623 N/m²	2.379 N/m²	4.533 N/m²	7.716 N/m²	12.136 N/m²
500/750			827 N/m²	1.211 N/m²	2.307 N/m²	3.923 N/m²	6.169 N/m²
600/900			477 N/m²	699 N/m²	1.329 N/m²	2.260 N/m²	3.546 N/m²
700/1050						1.418 N/m²	2.226 N/m²
800/1200						948 N/m²	1.487 N/m²
900/1350						664 N/m²	1.042 N/m²
1000/1500							758 N/m²
1200/1800							

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 5

Berolina-HF-Liner Table of short-term ring stiffness (SR) Part 1

Short term modulus of elasticity **17,000 N/mm²** Berolina-HF liner UP and VE resins

non-load bearing layers: Wear layer 0.5 mm; outer foil 0.3 mm = 0.8 mm (is not taken into consideration in the structural calculations)

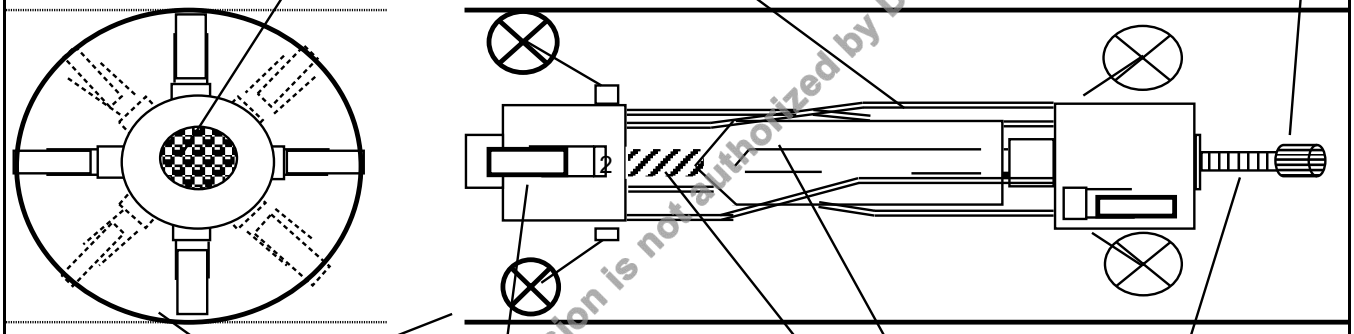
Liner thickn	9,0	10,0	11,0	12,0	13,0	14,0	15,0	16,0
DN 150								
DN 200								
DN 225								
DN 250								
DN 300	264.846 N/m²							
DN 315	227.614 N/m²							
DN 350	164.242 N/m²							
DN 375	132.721 N/m²							
DN 400	108.776 N/m²	154.811 N/m²						
DN 450	75.721 N/m²	107.672 N/m²	147.746 N/m²					
DN 480	62.116 N/m²	88.288 N/m²	121.094 N/m²					
DN 500	54.811 N/m²	77.884 N/m²	106.796 N/m²					
DN 550	40.942 N/m²	58.145 N/m²	79.684 N/m²					
DN 580	34.808 N/m²	49.419 N/m²	67.705 N/m²	90.110 N/m²				
DN 600	31.385 N/m²	44.550 N/m²	61.024 N/m²	81.203 N/m²	105.493 N/m²			
DN 650	24.585 N/m²	34.884 N/m²	47.764 N/m²	63.533 N/m²	82.504 N/m²			
DN 675	21.913 N/m²	31.088 N/m²	42.559 N/m²	56.600 N/m²	73.487 N/m²			
DN 700	19.615 N/m²	27.823 N/m²	38.084 N/m²	50.640 N/m²	65.738 N/m²	83.629 N/m²		
DN 750	15.900 N/m²	22.547 N/m²	30.852 N/m²	41.012 N/m²	53.223 N/m²	67.689 N/m²		
DN 800	13.067 N/m²	18.524 N/m²	25.341 N/m²	33.677 N/m²	43.694 N/m²	55.555 N/m²		
DN 850	10.869 N/m²	15.404 N/m²	21.069 N/m²	27.993 N/m²	36.310 N/m²	46.157 N/m²		
DN 883	9.682 N/m²	13.720 N/m²	18.763 N/m²	24.925 N/m²	32.327 N/m²	41.088 N/m²	51.328 N/m²	63.172 N/m²
DN 900	9.137 N/m²	12.948 N/m²	17.705 N/m²	23.519 N/m²	30.501 N/m²	38.764 N/m²	48.422 N/m²	59.592 N/m²
DN 1000	9.638 N/m²	9.403 N/m²	12.853 N/m²	17.068 N/m²	22.127 N/m²	28.112 N/m²	35.104 N/m²	43.186 N/m²
DN 1050	5.725 N/m²	8.109 N/m²	11.083 N/m²	14.715 N/m²	19.074 N/m²	24.230 N/m²	30.252 N/m²	37.212 N/m²
DN 1100	4.973 N/m²	7.042 N/m²	9.624 N/m²	12.776 N/m²	16.558 N/m²	21.031 N/m²	28.255 N/m²	32.290 N/m²
DN 1136	4.511 N/m²	6.387 N/m²	8.728 N/m²	11.586 N/m²	15.015 N/m²	19.069 N/m²	23.803 N/m²	29.272 N/m²
DN 1170	4.125 N/m²	5.841 N/m²	7.981 N/m²	10.594 N/m²	13.728 N/m²	17.433 N/m²	21.759 N/m²	26.757 N/m²
DN 1200	3.821 N/m²	5.410 N/m²	7.392 N/m²	9.810 N/m²	12.712 N/m²	16.142 N/m²	20.146 N/m²	24.772 N/m²
DN 1250	3.377 N/m²	4.781 N/m²	6.531 N/m²	8.668 N/m²	11.230 N/m²	14.259 N/m²	17.795 N/m²	21.878 N/m²
DN 1300	2.999 N/m²	4.246 N/m²	5.800 N/m²	7.696 N/m²	9.970 N/m²	12.658 N/m²	15.795 N/m²	19.418 N/m²
DN 1400		3.393 N/m²	4.634 N/m²	6.148 N/m²	7.964 N/m²	10.109 N/m²	12.612 N/m²	15.502 N/m²
DN 1500		2.754 N/m²	3.761 N/m²	4.989 N/m²	6.461 N/m²	8.200 N/m²	10.230 N/m²	12.572 N/m²
DN 1600		2.266 N/m²	3.094 N/m²	4.104 N/m²	5.314 N/m²	6.744 N/m²	8.412 N/m²	10.336 N/m²
d cross-sections								
200/300								
250/375	75.721 N/m²							
300/450	43.306 N/m²							
350/525	27.043 N/m²	38.378 N/m²	52.556 N/m²					
400/600	18.003 N/m²	25.533 N/m²	34.945 N/m²					
500/750	9.137 N/m²	12.948 N/m²	17.705 N/m²	23.519 N/m²	30.501 N/m²			
600/900	5.257 N/m²	7.445 N/m²	10.175 N/m²	13.508 N/m²	17.508 N/m²	22.239 N/m²		
700/1050	3.297 N/m²	4.667 N/m²	6.376 N/m²	8.461 N/m²	10.962 N/m²	13.918 N/m²	17.369 N/m²	21.354 N/m²
800/1200	2.202 N/m²	3.116 N/m²	4.255 N/m²	5.645 N/m²	7.312 N/m²	9.281 N/m²	11.578 N/m²	14.231 N/m²
900/1350	1.543 N/m²	2.183 N/m²	2.980 N/m²	3.953 N/m²	5.118 N/m²	6.495 N/m²	8.101 N/m²	9.954 N/m²
1000/1500	1.122 N/m²	1.588 N/m²	2.167 N/m²	2.874 N/m²	3.721 N/m²	4.721 N/m²	5.887 N/m²	7.233 N/m²
1200/1800		916 N/m²	1.250 N/m²	1.657 N/m²	2.145 N/m²	2.720 N/m²	3.391 N/m²	4.165 N/m²

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 6

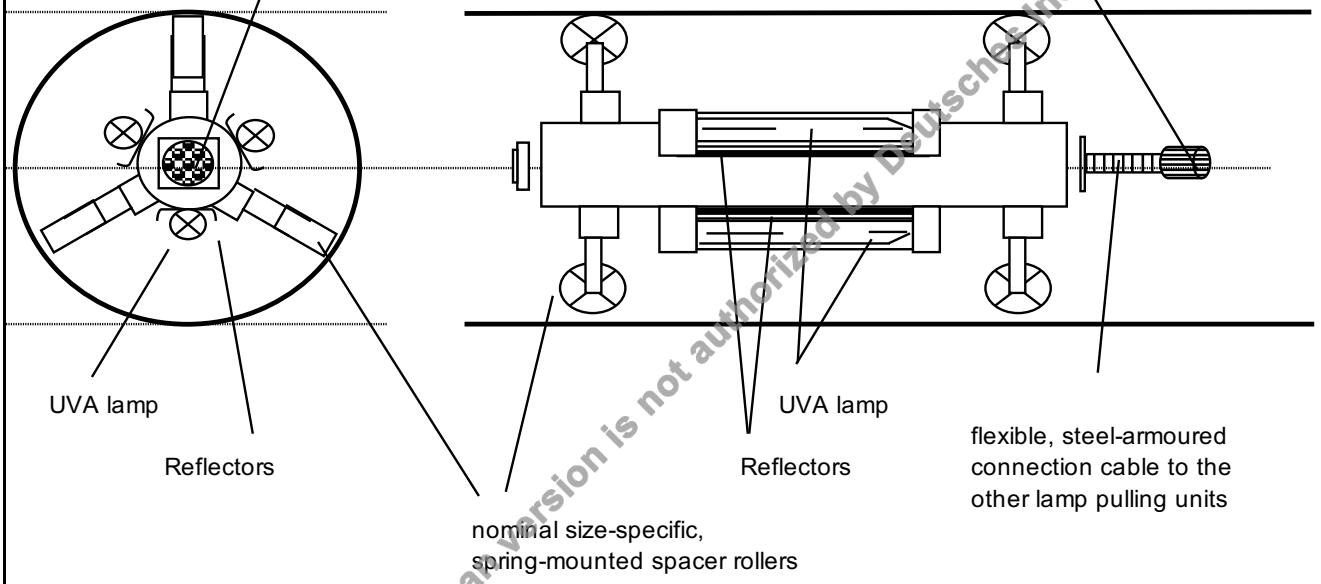
Berolina-HF-Liner Table of short-term ring stiffness (SR) Part 2

UV lamp pulling unit for DN 150 to DN 300



Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 7**
Schematic diagram of an element of a UV light train	

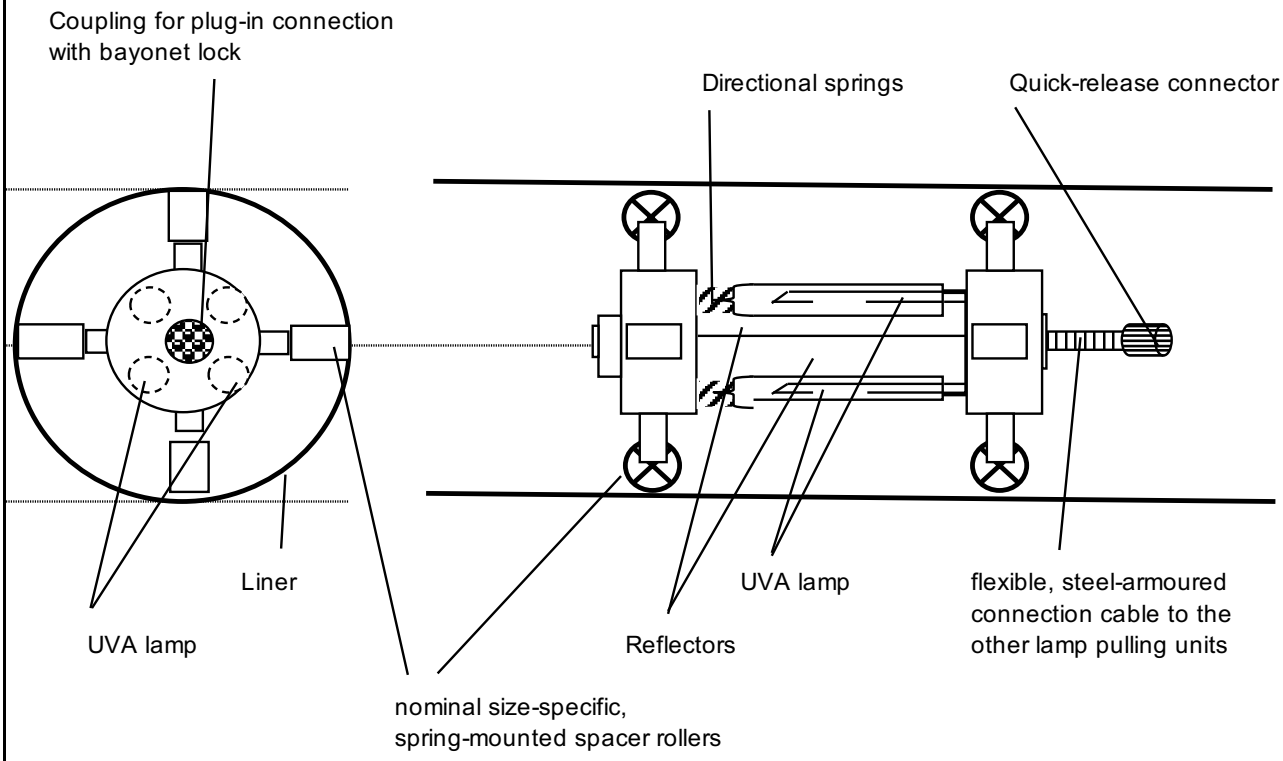
UV lamp pulling unit for DN 400 to DN 600



3 UVA lamps are mounted on each lamp pulling unit;
up to 4 units can be plugged together to form a light train

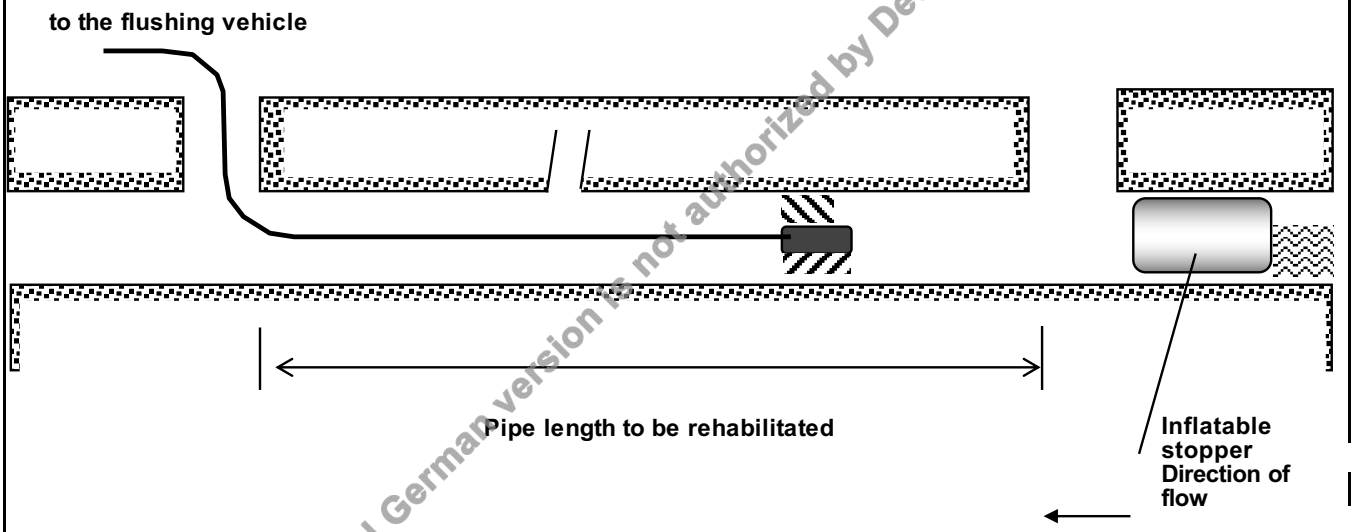
Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 8**
Schematic diagram of an element of a UV light train	

UV lamp pulling unit for DN 600 and larger

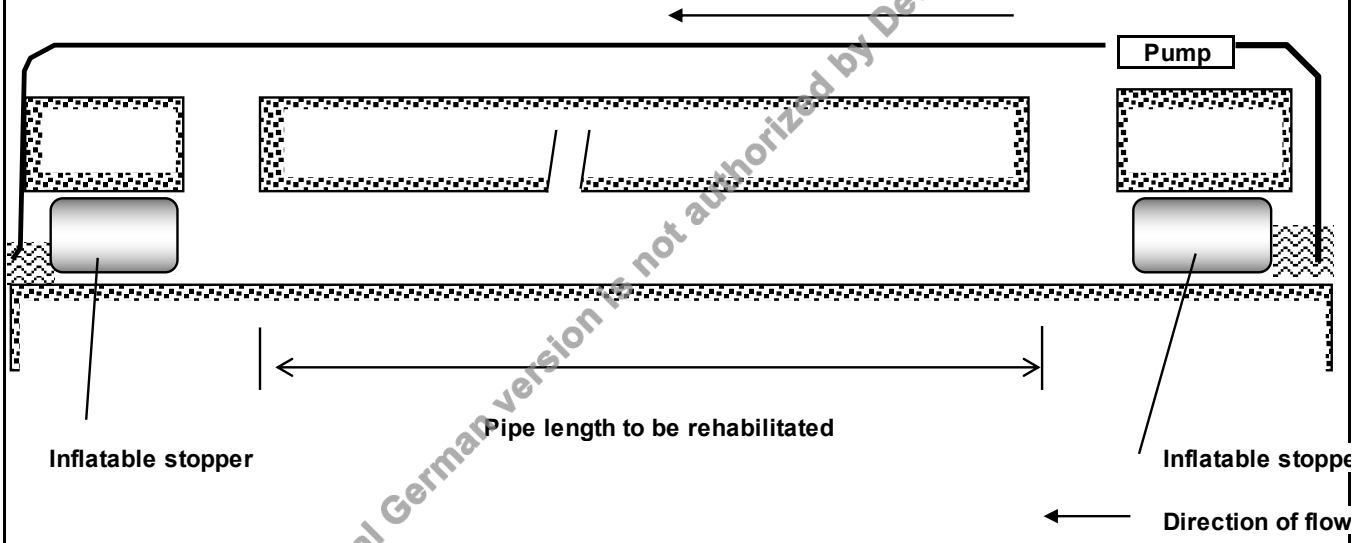


4 UVA lamps are mounted on each lamp pulling unit;
up to 3 units can be plugged together to form a light train

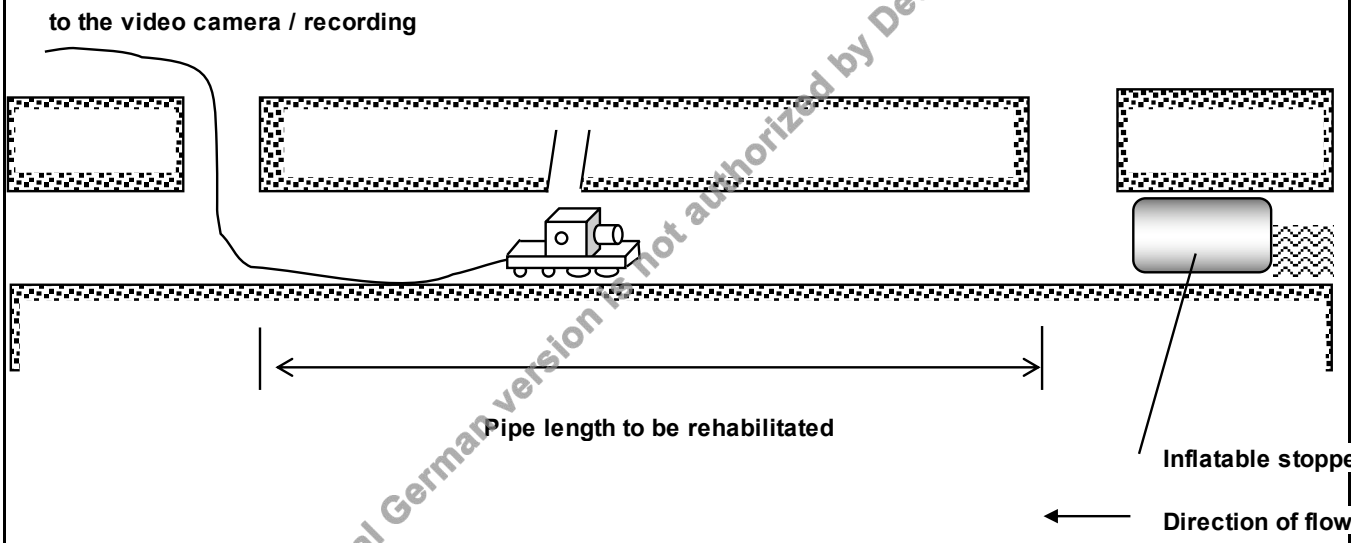
Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (under-ground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 9**
Schematic diagram of an element of a UV light train	



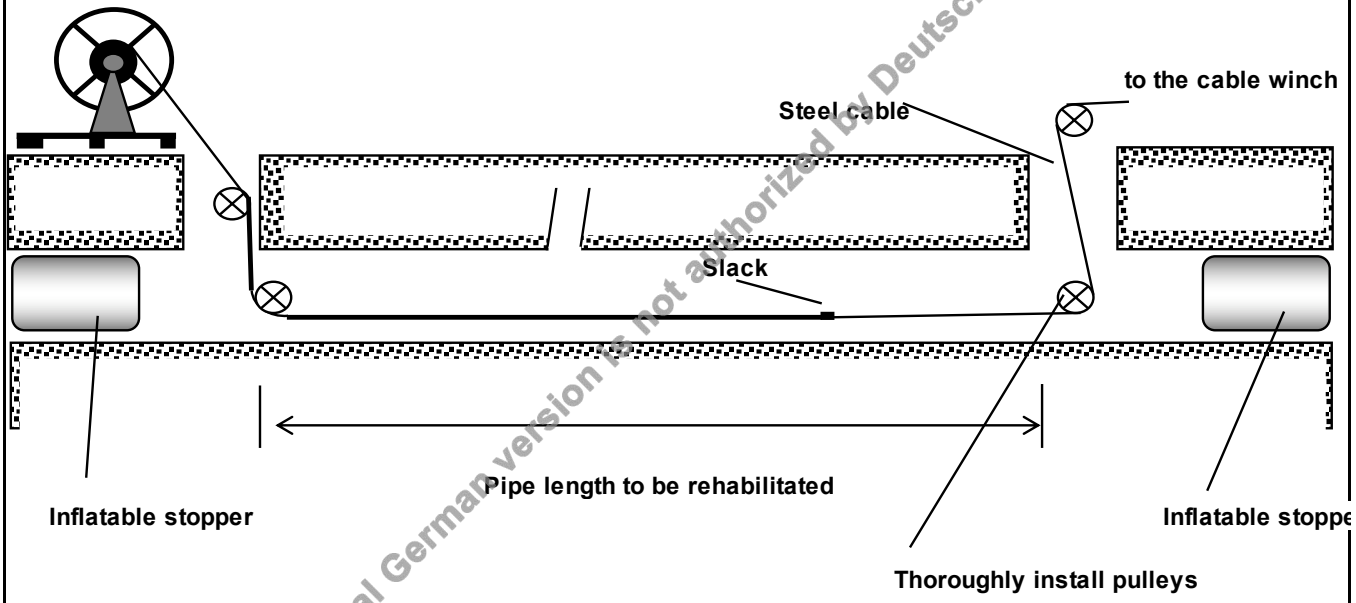
Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 10**
Schematic diagram of sewer cleaning using pipe jetter	



Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 11**
Schematic diagram of a pipe length with a bypass	

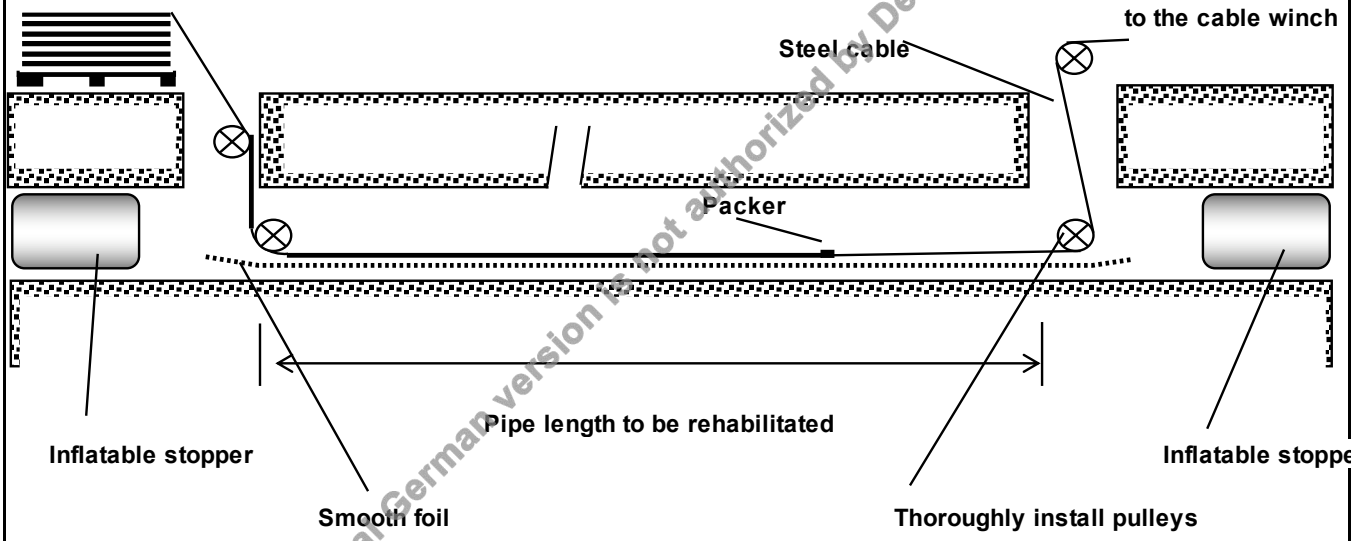


Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 12**
Schematic diagram of CCTV inspection and single pipe length	

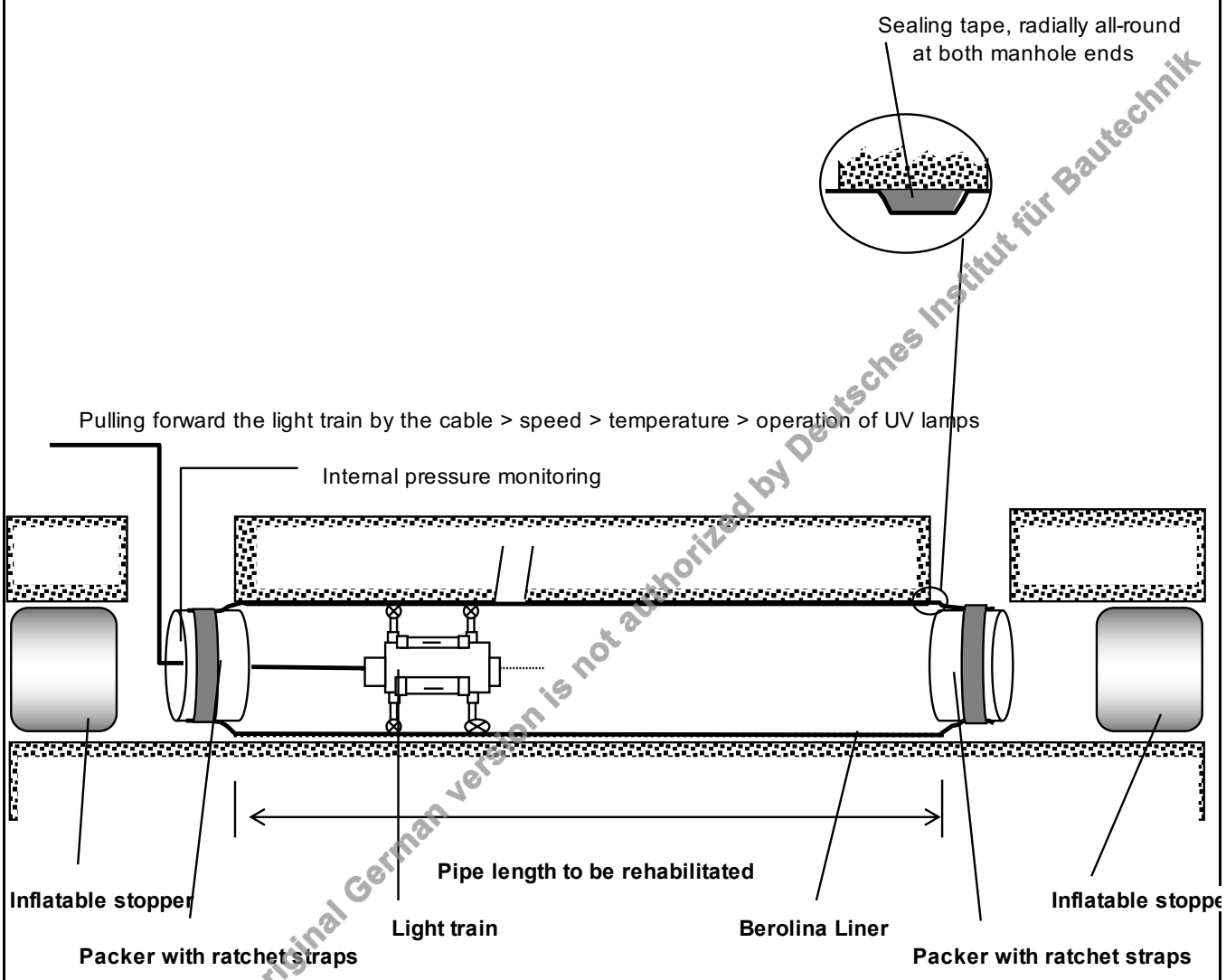


Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 13**
Schematic diagram of pulling in the smooth foil	

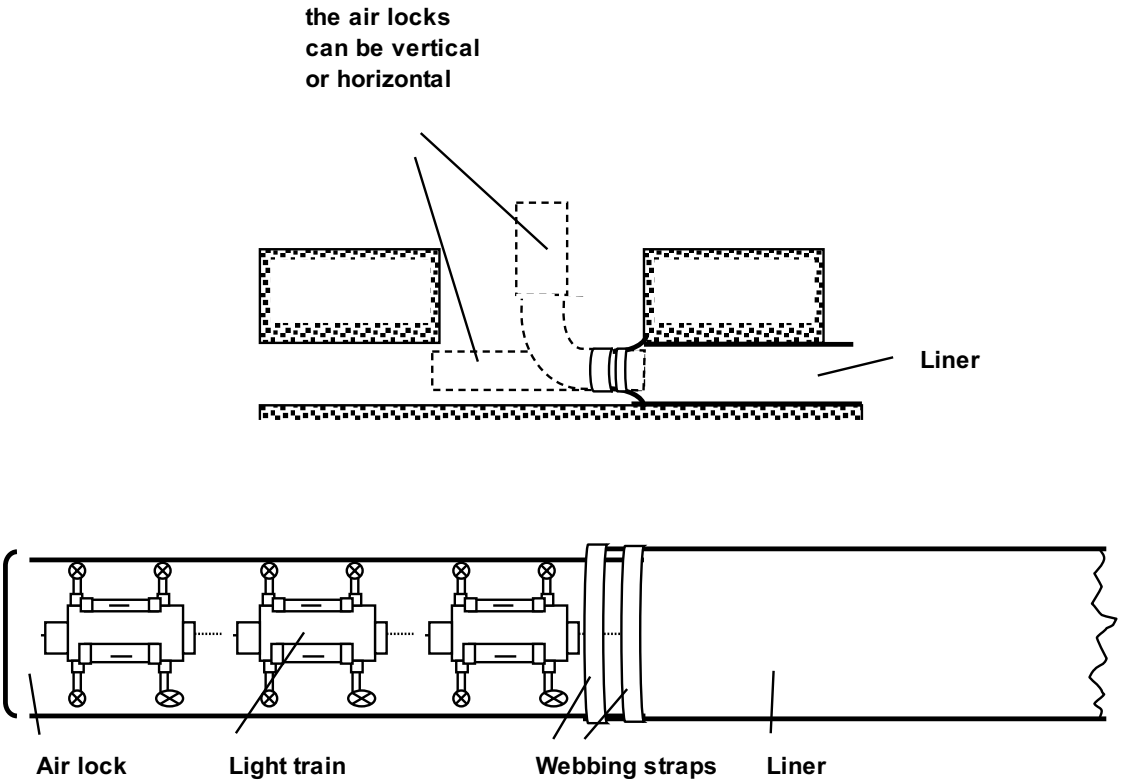
when pulling the liner into the sewer, protect it against lateral damage



Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 14**
Schematic diagram of pulling in the liner	



Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 15**
Schematic diagram of the liner curing by means of the light train	



A pipe or hose, which is connected to the liner, can be used as an air lock.
In this way, the light train can be pulled into the liner that has been inflated with compressed air.

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 16**
Schematic diagram of air locks for pulling in lamps	

Nominal thickness / DN	3,5 mm	4,0 mm	4,5 mm	5 mm	6 mm	7 mm	8 mm	9 mm	10 mm	11 mm	12 mm	13 mm	14 mm	15 mm	16 mm
150	21	20	19	18											
200	20	18	17	16	14	13									
225	19	16	15	14	13	12	11								
250	18	15	14	13	11	10	9	8							
300	16	14	13	12	10	9	8	7							
350	14	12	11	10	9	8	7	6							
380	12	11	9	8	7	6	4,5	3,5							
400		8	7,5	7	6	5	4	3	2						
450		7	7,5	6	5	4,5	3	2,5	2,5	2					
500		6	5,5	5	4	3,5	2,5	2	2	1					
550		5	4,5	4	3,5	3	2	2	2	1					
600			4	3,5	3	2,5	2	1,5	1	1	0,5				
700			7,5	7	6,5	6	5,5	5	4,5	3	3,5	3	2,5		
750			7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2		
800			6,5	6	5,5	5	4,5	4	3,5	2,5	2	1,5	1		
900						4	3,5	3	2,5	2	1,5	1	1		
1000						3,5	3	2,5	2	1,5	1	1	1	0,5	0,4
1100						3	2,5	2	1,5	1	1	1	1	0,5	0,4
1200						2,5	2	1,5	1,5	1	1	1	1	0,5	0,4
1300							1,5	1	1	1	1	0,5	0,5	0,5	0,4
1400									0,5	0,5	0,5	0,3	0,3	0,3	0,3
1500									0,3	0,3	0,3	0,2	0,2	0,2	0,2
1600									0,2	0,2	0,2	0,2	0,1	0,1	0,1

All figures in cm × min

the feed speeds given in this table apply equally to the Berolina liner and the Berolina-HF liner

DN	Light chains or light cores 6 to 12 lamps	Liner thicknesses mm	Feed speed cm × min.$^{-1}$ min.	max.
150	Light chain 400 W	3.5 - 5.0	**76**	**112**
200	Light chain 400 W	3.5 - 7.0	**58**	**106**
225	Light chain 400 W	3.5 - 7.0	**56**	**101**
250	Light chain up to 650 W	3.5 - 8.0	**58**	**138**
275	Light chain up to 650 W	3.5 - 8.0	**50**	**133**
300	Light chain up to 650 W	3.5 - 9.0	**41**	**129**
350	Light chain up to 650 W	3.5 - 9.0	**36**	**121**
375	Light chain up to 650 W	3.5 - 9.0	**35**	**118**
400	Light chain up to 650 W	3.5 - 10.0	**28**	**114**
450	Light chain up to 650 W	4.0 - 11.0	**22**	**101**
500	Light chain or cores up to 1200 W	4.0 - 11.0	**19**	**94**
600	Light chain or cores up to 1200 W	4.5 - 13.0	**11**	**85**
700	Light chain or cores up to 1200 W	5.0 - 14.0	**11**	**79**
800	Light chain or cores up to 1200 W	5.0 - 14.0	**10**	**71**
900	Light chain or cores up to 1200 W	7.0 - 15.0	**9**	**55**
1000	Light chain or cores up to 1200 W	7.0 - 15.0	**8**	**52**
1100	Light chain or cores up to 1200 W	7.0 - 15.0	**8**	**48**
1200	Light chain or cores up to 1200 W	7.0 - 15.0	**8**	**44**
1300	Light chain or cores up to 1200 W	8.0 - 15.0	**8**	**32**
1400	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**20**
1500	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**18**
1600	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**13**

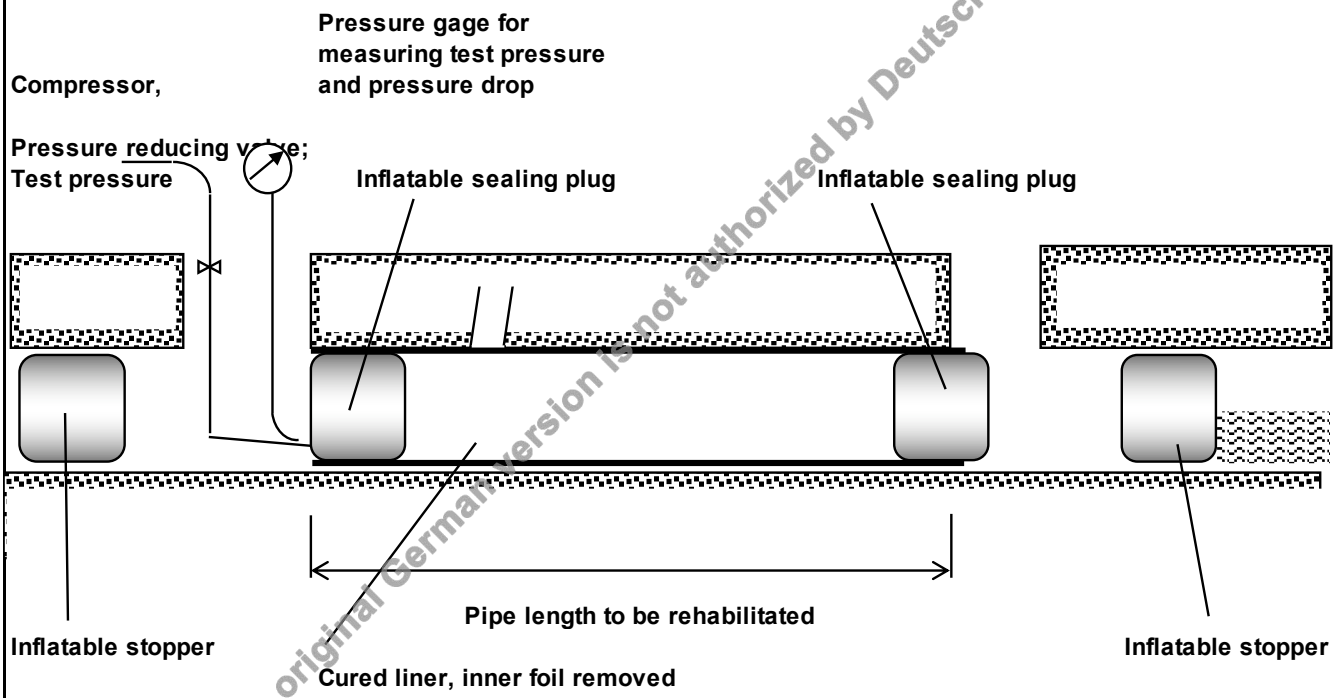
void cross-section	Light chains or light cores 6 to 12 lamps	Liner thicknesses mm	Feed speed cm × min.$^{-1}$ min.	max.
200 / 300	Light chain up to 650 W	3.5 - 7.0	**41**	**129**
250 / 375	Light chain up to 650 W	3.5 - 8.0	**35**	**118**
300 / 450	Light chain up to 650 W	4.0 - 8.0	**22**	**101**
350 / 525	Light chain up to 650 W	5.0 - 10.0	**13**	**90**
400 / 600	Light chain up to 650 W	6.0 - 11.0	**11**	**85**
500 / 750	Light chain up to 650 W	7.0 - 12.0	**10**	**73**
600 / 900	Light chain or cores up to 1200 W	8.0 - 13.0	**9**	**55**
700 / 1050	Light chain or cores up to 1200 W	9.0 - 13.0	**8**	**48**
800 / 1200	Light chain or cores up to 1200 W	9.0 - 13.0	**8**	**44**
840 / 1260	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**32**
900 / 1350	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**24**
1000 / 1500	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**18**
1100 / 1650	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**12**
1200 / 1800	Light chain or cores up to 1200 W	10.0 - 15.0	**8**	**9**

the feed speeds given in this table apply equally to the Berolina liner and the Berolina-HF liner

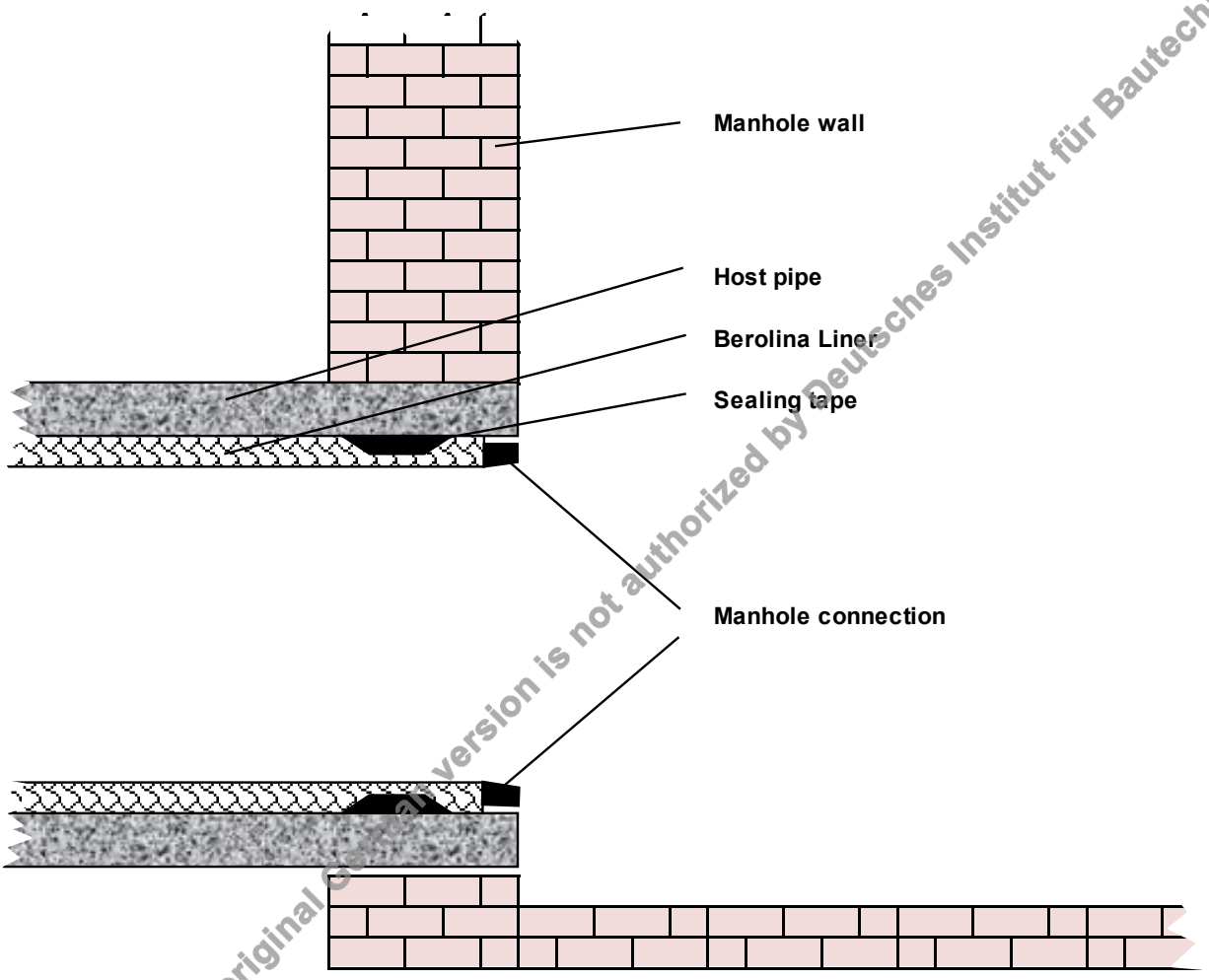
Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 18

Feed speeds - liner curing



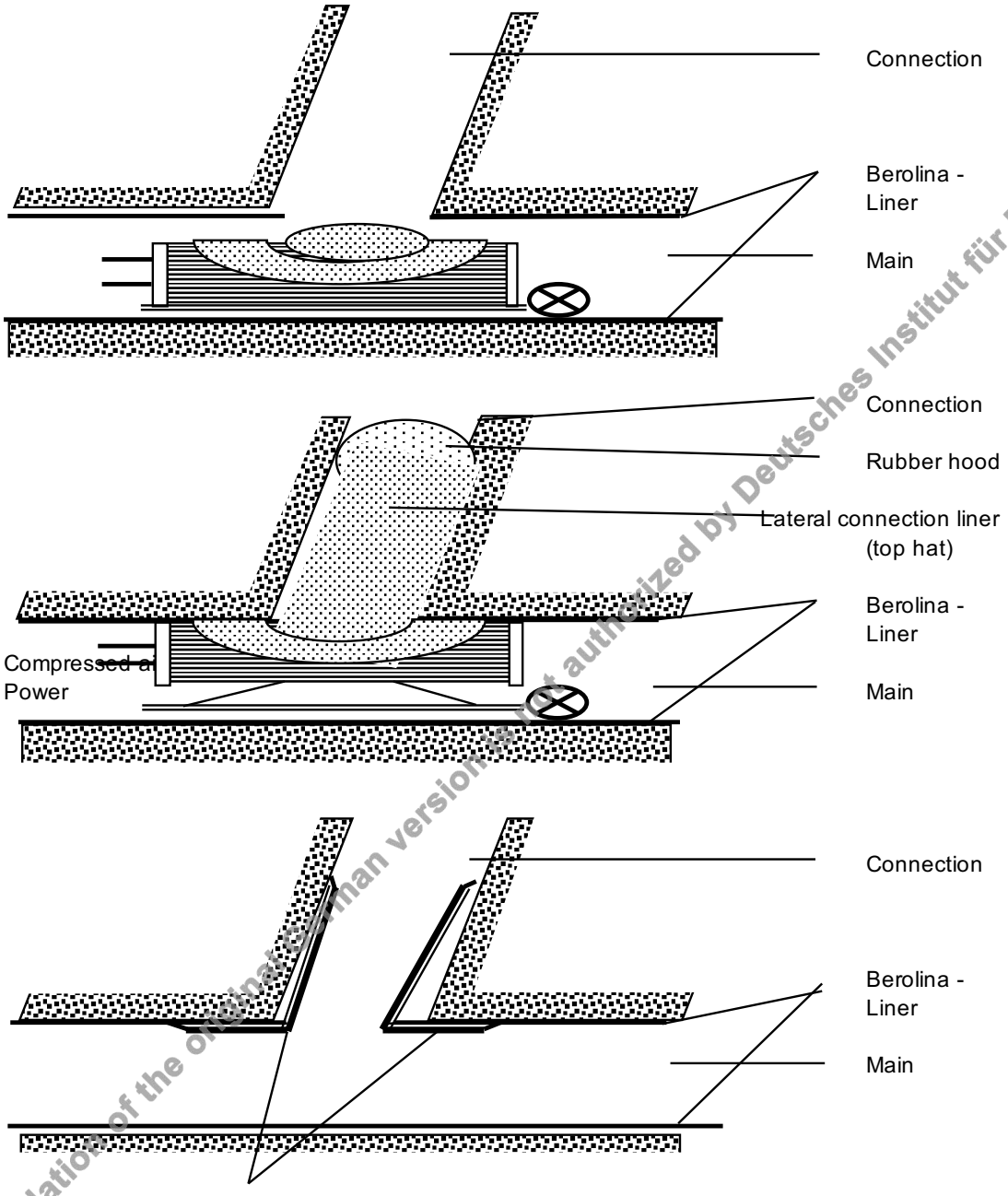
Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 19**
Schematic diagram of leak test to EN 1610	



Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm

Appendix 20

Schematic diagram of a manhole connection

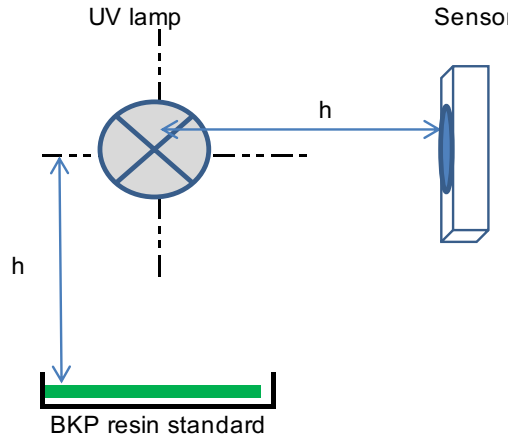


Finished lateral connection liner (top hat)

1 Cut open lateral pipe connection
2 Position lateral connection liner on rubber hood and move into position using installation vehicle
3 Apply compressed air to rubber hood and apply liner laminate to the jointing/connection point
4 Curing through UVA radiation
5 Pull out the rubber hood, move out the robot unit

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 21**
Connection of lateral inlet pipes by means of collar technique	

Schematic diagram



The relevant electrical power (k) for the lamps to be tested must be set at the electronic control gear for the lamp type;
Electronic control gear TEP 20-T uv technik meyer

The spectral sensitivity of the test sensors must correspond to the UV sensitivity of the resins used;
BKP uses 2 sensors with overlapping spectrums.
UV meter 086001 Dr.Hönle AG
UV probe FS LED D2 E210 Dr.Hönle AG
UV probe FS VIS D1 E210 Dr.Hönle AG

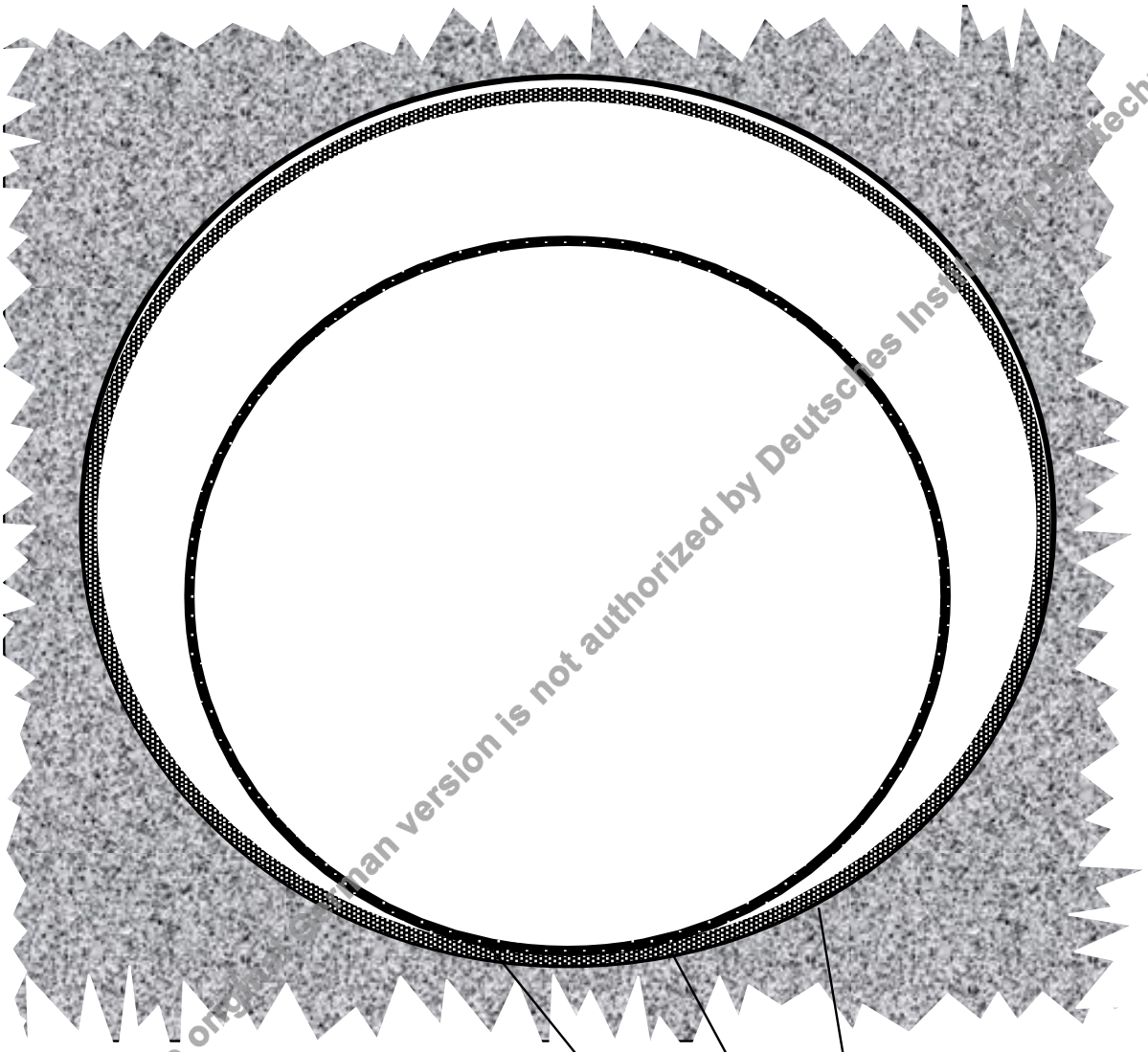
When measuring the lamps, at the same time 1x a resin sample (50g in Petri dish) is also cured, and the peak, peak time and Barcol hardness are measure

Lamp type	Distance h to the lamp axis mm	Power setting at power supply unit	VIS sensor mW / cm²	LED sensor mW / cm²	Resin standard Peak °C	Resin standard Peak time sec.	Resin standard Barcol hardness scale di
400W	**150**	**1,80**	**≥ 31**	**≥ 37**	**≥ 165**	**≤ 145**	**≥ 43**
400 / 600 W	**150**	**1,70**	**≥ 48**	**≥ 56**	**≥ 165**	**≤ 145**	**≥ 43**
1000W	**250**	**5,00**	**≥ 36**	**≥ 42**	**≥ 165**	**≤ 145**	**≥ 43**

Guide values to be complied with for characteristic-compatible liner curing

The UV output of the UV lamps used for liner curing must be checked cyclically for the first time after approx. 700 operating hours (incl. 1h added for each switching operation).

The following tests on the UV lamps must take place after approx. 120 further operating hours at the latest.



after it has been pulled in, the liner is inflated with compressed air; the seaming compound or a sealing or swelling tape is then applied in the host pipe; the Berolina is then moved into the sealing compound;

Construction products and their use to execute tube liners with designation "Berolina - Liner" and "Berolina - HF - Liner" for the rehabilitation of buried (underground) damaged sewers with circular cross-sections in nominal sizes DN 150 to DN 1600 and ovoid cross-sections in nominal sizes 200/300 mm to 1200/1800 mm	**Appendix 23**
Schematic diagram showing attachment of a sealing tape	

UVRec - Aufzeichnung

BKP Berolina
Heidering 28
D-16727 Velten

Auftraggeber

Telefon: Telefon -Gesch.:
Telefax: Telefax -Gesch.:
Mobil: Email:

Auftragnehmer

BKP Berolina Polyester GmbH & Co.KG

Heidering 28

D-16727 Velten

+49 3304 2088 100
Wall thickness:
info@bkp-berolina.de

Objekt

Name: **Auftragnr.:**
Strasse: **Projektnr.:**
Ort: **Datum:**

Von: **Profil:**
Nach: **Länge:** m
Operator: **Wetter:** **Temp.:** °C

Hersteller, Typ: BKP Berolina Polyester, Berolina-Liner **Liner Nummer:**
Datum Herstellung: **Lager Temp.:** °C **Wandstärke:** mm **L.Länge:** m

Aufgezeichnete Werte

UVDaten Datei: **Datum:**
Video:

Anzahl Werte: **Aufzeichnung Dauer:** **Anzahl Bilder:** 0

Temperatur Liner BackEye:	**Min =**	**Max =**	**Durchschnitt =**	°C
Temperatur Liner Mitte:	**Min =**	**Max =**	**Durchschnitt =**	°C
Temperatur Liner Frontk.:	**Min =**	**Max =**	**Durchschnitt =**	°C
Druck im Liner:	**Min =**	**Max =**	**Durchschnitt =**	mbar
Luftemperatur im Liner:	**Min =**	**Max =**	**Durchschnitt =**	°C
Zuggeschwindigkeit:	**Min =**	**Max =**	**Durchschnitt =**	m/min
Ausgewählte Leistung:	**Min =**	**Max =**	**Durchschnitt =**	Watt
Volumestrom des Blowers:	**Min =**	**Max =**	**Durchschnitt =**	%

PROTOKOLL ZUR DICHTHEITSPRUFUNG DER ABWASSERLEITUNGEN in Anlehnung an DIN EN 1610

1. Angaben zum Bauvorhaben:

Bauvorhaben:			
Anschrift:		PLZ/Ort:	
Auftraggeber:			
Anschrift:		PLZ/Ort:	
Sanierungsfirma:			
Anschrift:			
Herstellertyp:	○ Schlauchliner ○ Kurzliner	Produktbezeichnung:	
Dichtheitsprüfung:			
Anschrift:		PLZ/Ort:	

2. Angaben zum Abwasserkanal / -leitung:

Abwasserart:	○ Schmutzwasser	○ Regenwasser	○ Mischwasser		
Rohrgeometrie:	○ Kreisprofil	○ Eiprofil			
Linermaterial:		Nennweite:		Sanierungsdatum:	
Haltungsnummer:					
Haltungslänge:					
von Schacht:		bis Schacht:			

3. Dichtheitsprüfung mit Luft:

Prüfmethode:	○ LA		○ LB		○ LC	○ LD
Prüfdruck p_0:		mbar	Beruhigungszeit:			mbar
zul. Druckabfall Δp:		mbar	Prüfdauer:			mbar
Druck zu Beginn:		mbar				
Druck am Ende:		mbar	Druckabfall:			mbar

4. Dichtheitsprüfung mit Wasser:

○ nur Rohrleitungen	○ Schächte und Inspektionsöffnungen	○ Rohrleitung mit Schacht
Prüfdauer:		30 min
Höhe der Wassersäule über Rohrscheitel zu Beginn der Prüfung:		kPa (= mWS · 10)
Wasserzugabe:		l
Wasserzugabe / Haltungslänge:		l/m²
Zulässige Wasserzugabe pro m² benetzter Umfang gem. nach DIN EN 1610:		0,15 l/m²
Rechnerische zul. Gesamt-Wasserzugabe bezogen auf die Prüfstrecke:		l
tatsächliche Wasserzugabe:		l

5. Ergebniss

Prüfung bestanden:	○ ja	○ nein
Bemerkungen:		
Ort / Datum:		Unterschrift:

Berolina-Liner System	**APS - Probenbegleitschein** (Arbeitskreis Prüfinstitut Schlauchliner) **zur Materialprüfung Schlauchliner**	BKP BEROLINA

☐ **Erstprüfung** ☐ **Wiederholungsprüfung** zu Prüfbericht Nr.: _____

Angaben zur Probenentnahme

Überwachung durch (Name)	Probenentnahme		Bestätigung der Probenentnahme (ausführende Firma/Bauleitung)	
	Datum	Uhrzeit	Druckbuchstaben	Unterschrift

Probenidentifikation

Auftraggeber Materialprüfung			Material - ID			
Bauherr			Haltungsbezeichnung			
Bauvorhaben			Probenbezeichnung			
Ausführende Firma			Einbaudatum			
Hersteller (Liner)	BKP Berolina		Altrohrzustand	☐ I	☐ II	☐ III
Material	Harz	Träger	Entnahmestelle	Haltung ☐	Endschacht ☐	ZW-Schacht ☐
Rohrgeometrie	☐ Kreis ☐ Ei		Entnahmeposition	Scheitel ☐	Kämpfer ☐	Sohle ☐

Geforderte Kurzzeiteigenschaften gemäß Auftraggeber

Biege-E-Modul E_f [N/mm²]		Umfangs-E-Modul E_U [N/mm²]	
Biegespannung σ_{fB} [N/mm²]		Anfangs-Ringsteifigkeit S_0 [N/m²]	
statisch tragende Wanddicke h [mm]		max. Kriechneigung K_{n24} [%]	
Abminderungsfaktor für dauernde Lasten A_1		Dichte ρ [g/cm³]	

Prüfergebnisse (durchzuführende Prüfungen bitte ankreuzen!)

☐ **Biege-E-Modul, Biegespannung** nach DIN EN ISO 178/DIN EN 13566-4 — **24h-Kriechneigung** in Anlehnung an DIN EN ISO 899-2 ☐

Prüfdatum	E_f [N/mm²]	σ_{fB} [N/mm²]	h [mm]		K_{n24} [%]
		Prüfrichtung	☐ axial	☐ radial	

☐ **Umfangs-E-Modul, Anfangs-Ringsteifigkeit** nach DIN EN 1228 — **24h-Kriechneigung** in Anlehnung an DIN EN 761 ☐

Prüfdatum	E_U [N/mm²]	S_0 [N/m²]	h [mm]	K_{n24} [%]

☐ **Wasserdichtheit** nach APS - Richtlinien

Prüfdatum	Prüfzeit [min]	Prüfdruck [bar]	Prüfergebnis	
	30	0,5 ± 5%	☐ dicht	☐ undicht

☐ **Kalzinierungsverfahren** nach DIN EN ISO 1172

Prüfdatum	Harzanteil [%]	Rückstand gesamt [%]	Glasanteil [%]	Zuschlagstoff [%]

☐ **Spektralanalyse** in Anlehnung an ASTM D5576 (FT-IR)

Prüfdatum	Harz

☐ **Dichte** nach DIN EN ISO 1183-1

Prüfdatum	Dichte ρ [g/cm³]

☐ **Thermische Analyse** nach DIN EN ISO 11357-1/DIN 53765 (DSC-Messung)

Prüfdatum	Glasübergangstemperatur T_G [C°]				Enthalpie [J/g]	
	$T_{G\,H1}$		ΔT_G		☐ exotherm	☐ endotherm
	$T_{G\,H2}$					

☐ **Reststyrolgehalt** nach DIN 53394-2 (GC)

Prüfdatum	Einwaage [mg]	Reststyrolgehalt [mg/kg]	Reststyrolgehalt [%]	Einwaage bezogen auf	
				Gesamteinwaage	Reinharz
				☐	☐

Bewertung der Prüfergebnisse

Anforderung	erfüllt	nicht erfüllt
Biege-E-Modul	☐	☐
Biegespannung	☐	☐
Wanddicke	☐	☐
Wasserdichtheit	☐	☐
Bemerkung		

Anforderung	erfüllt	nicht erfüllt
Umfangs-E-Modul	☐	☐
Anfangs-Ringsteifigkeit	☐	☐
24h-Kriechneigung	☐	☐
Dichte	☐	☐

_____

Datum, Unterschrift Prüfer/Laborleiter

Berolina-Liner

Einsatzbereiche von Winden

Nenndurchmesser		Berolina-Liner Wanddicke													
DN	Ei-Profil	3,5	4	4,5	5	6	7	8	9	10	11	12	13	14	15
150		A	A	A	A										
200		A	A	A	B	B	B	B							
225		A	A	A	B	B	B	B							
250	200/300	A	A	A	B	B	B	B							
275		A	B	B	B	B	B	B							
300		A	B	B	B	B	B	B	C						
315	250/375	A	B	B	B	B	C	C	C						
350		A	B	B	B	B	C	C	C						
375	300/450	A	B	B	B	B	C	C	C						
400		B	B	B	C	C	C	C	C	C					
450	350/525		B	B	C	C	C	C	C	C	C				
480			B	B	C	C	C	C	C	C	C				
500	400/600		B	B	C	C	C	C	C	C	C				
525				C	C	C	C	C	C	C	C				
550				C	C	C	C	C	C	C	C				
580				C	C	C	C	C	C	C	C				
600				C	C	C	C	C	C	C	C	C	C		
631	500/750			C	C	C	C	C	C	C	C	C	C		
650				C	C	C	C	C	C	C	C	C	C		
675				C	C	C	C	C	C	C	C	C	C		
700				C	C		C	C	C	C	C	C	C	C	
750	600/900			C	C	C	C	C	C	C	C	C	C	C	
800				C	C	C	C	C	C	C	C	C	C	C	
850						C	C	C	C	C	C	C	C	C	
883	700/1050						C	C	C	C	C	C	C	C	C
900							C	C	C	C	C	C	C	C	C
950							C	C	C	C	C	C	C	C	C
1000	800/1200						C	C	C	C	C	C	C	C	C
1050							C	C	C	C	C	C	C	C	C
1100							C	C	C	C	C	C	C	C	C
1136	900/1350						C	C	C	C	C	C	C	C	C
1150							C	C	C	C	C	C	C	C	C
1200							C	C	C	C	C	C	C	C	C
1250								C	C	C	C	C	C	C	C
1275	1000/1500							C	C	C	C	C	C	C	C
1300								C	C	C	C	C	C	C	C
1350								C	C	C	C	C	C	C	C
1400										C	C	C	C	C	C
1500	1200/1800									C	C	C	C	C	C
1600										C	C	C	C	C	C

A = Winde mit Zugkraftbegrenzung auf maximal 5 t (49 kN).

B = Winde mit Zugkraft von 5 t bis zu max. 10 t (49 kN bis zu max. 98 kN).

C = Winde mit Zugkraft von 5 t bis zu max. 20 t (49 kN bis zu max. 196 kN).

Berolina-HF-Liner

Einsatzbereiche von Winden

Durchmesser (mm)		Berolina-HF-Liner Wanddicke (mm)													
DN	Ei-Profil	3,5	4	4,5	5	6	7	8	9	10	11	12	13	14	15
150															
200															
225															
250	200/300														
275															
300															
315	250/375														
350															
375	300/450														
400															
450	350/525														
480															
500	400/600														
525															
550															
580															
600															
631	500/750														
650															
675															
700						B	B	B	C	C	C	C	C	C	
750	600/900					B	B	B	C	C	C	C	C	C	
800						B	B	B	C	C	C	C	C	C	
850						B	B	C	C	C	C	C	C	C	
883	700/1050						B	C	C	C	C	C	C	C	C
900							B	C	C	C	C	C	C	C	C
950							B	C	C	C	C	C	C	C	C
1000	800/1200						B	C	C	C	C	C	C	C	C
1050							B	C	C	C	C	C	C	C	C
1100							B	C	C	C	C	C	C	C	C
1136	900/1350						C	C	C	C	C	C	C	C	C
1150							C	C	C	C	C	C	C	C	C
1200							C	C	C	C	C	C	C	C	C
1250							C	C	C	C	C	C	C	C	C
1275	1000/1500						C	C	C	C	C	C	C	C	C
1300							C	C	C	C	C	C	C	C	C
1350							C	C	C	C	C	C	C	C	C
1400							C	C	C	C	C	C	C	C	C
1500	1200/1800						C	C	C	C	C	C	C	C	C
1600							C	C	C	C	C	C	C	C	C

A = Winde mit Zugkraftbegrenzung auf maximal 5 t (49 kN).

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