neutral
unabhängig
gemeinnützig

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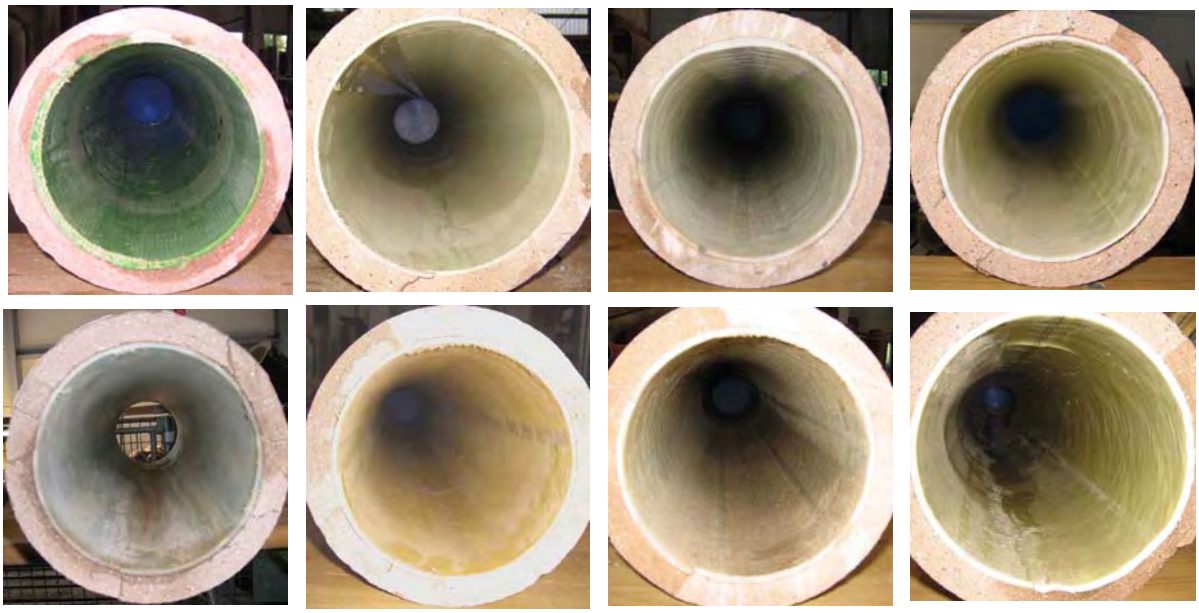
Product-Test

Tube Liners for Lateral Pipes

- Short Report -



Kaltenhäuser, G.

November 2005

IKT-Product-Test

Tube Liners for Lateral Pipes

Fourteen sewage network operators took part in the IKT-Product-Test "Tube Liners for Lateral Pipes". Many thanks to these network operators for their factual contributions to the test procedure during the nine sessions and for their involvement in assessing the systems:

- Eigenbetrieb Abwasser Stadt Alsdorf [Alsdorf municipal wastewater utility]
- Abwasserwerk Stadt Bergisch Gladbach [Bergisch Gladbach municipal sewage plant]
- Stadt Dinslaken [Dinslaken municipal authority]
- Stadtentwässerungsbetrieb Düsseldorf [Düsseldorf city wastewater utility]
- Stadt Gladbeck [Gladbeck municipal authority]
- Stadtentwässerung Göttingen [Göttingen city wastewater]
- Stadt Hilden [Hilden municipal authority]
- Stadtentwässerungsbetriebe Köln [Cologne city wastewater utility]
- Stadt Neuss [Neuss city authority]
- Niederrheinische Versorgung und Verkehr AG (NVV) [Lower Rhine Utility and Transport]
- Stadtwerke Quickborn [Quickborn municipal utility]
- Stadt Recklinghausen [Recklinghausen municipal authority]
- Entsorgungsbetriebe Warendorf [Warendorf disposal utility]
- Staatliches Hochbauamt Würzburg [State structural engineering department Würzburg]

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1 Introduction and objective

Lateral pipes are the link between public and private sewage systems. This link as part of domestic wastewater management is drawing increasing attention from the sewer branch. According to a survey of the German Association for Water, Wastewater and Waste (DWA) in 2004 [1], private sewage systems are in considerable need of action. But maintenance of the lateral pipes is a matter not only for the private connection users [2, 3, 4] but also for the public network operators [5].

Tube liners are being increasingly used to refurbish private sewage systems. But at the moment it is not clear to what extent these liners fulfil the requirements made of them. Both sewage network operators and private land owners are very uncertain when it comes to selecting and using suitable tube liners.

In this context, IKT has performed a comparison test of lateral pipes. To do so, it used the already existing test set-up funded by the MUNLV NRW in the IKT's large-scale test facility (see research project "Comparative tests of the quality of refurbishment methods for lateral pipes", Ref. IV-9-041 105 0180).

The aim of the IKT-Product-Test is to assess the quality of the products available on the market, to illustrate potential for improvements and at the same time to build up a corresponding market pressure so that the suppliers actually make use of this potential. The sewage network operator as customer stipulates which quality requirements are made of the products and how products are to be assessed in this context. 14 sewage network operators were involved in the IKT-Product-Test „Tube Liners for Lateral Pipes“: Alsdorf municipal wastewater utility, Bergisch Gladbach municipal sewage plant, Dinslaken municipal authority, Düsseldorf city wastewater utility, Gladbeck municipal authority, Göttingen city wastewater, Hilden municipal authority, Cologne city wastewater utility, neuss city authority, Lower Rhine Utility and Transport, Quickborn municipal utility, Recklinghausen municipal authority, Warendorf disposal utility and the State structural engineering department Würzburg.

2 Test programme

Altogether nine sessions were held to define the overall test contents – selection of the liners, test programme and assessment – with the sewage network operators. Attention was concentrated on three focal issues: **quality assurance, system tests** and **construction site investigations** (see [6], [7], [8]). The focal issues quality assurance and system tests form the basis of the test marks. The site investigation results cannot be included in ascertaining the test marks because the general conditions are incommensurable: these results are taken into account as additional information.

The sewage network operators stipulated the tube liners for the IKT-Product-Test „Tube Liners for Lateral Pipes“. The suppliers of these liners were then asked to take part in the test. Two suppliers, Mr. Pipe GmbH and Insituform Rohrsanierungstechniken GmbH, declined to participate in the test; the reasons are explained in the corresponding letters featured in Annex I and Annex II.

The following tube liners underwent comprehensive testing during the product test:

- BendiLiner, EasyLiner GmbH
- BRAWOLINER - FIX, Karl Otto Braun KG
- DrainLiner, epros GmbH
- DrainPlusliner, epros GmbH
- Flex-Liner, Alocit Chemie GmbH
- Konudur Homeliner, MC-Bauchemie Müller GmbH & Co. KG
- ProFlex Liner (Prototyp), Vereinigte Filzfabriken AG
- SoftLiner, EasyLiner GmbH

2.1 Quality assurance of the liner suppliers

The focal test issue "quality assurance by the liner suppliers" deals with the question: how does the supplier assist in refurbishment with his tube liner so as to achieve high quality results?

The IKT asked the suppliers of the tested tube liners to submit procedure certifications of Deutsches Institut für Bautechnik (DIBt), test certificates for the environment compatibility of the resin systems being used, procedure manuals and information about training courses together with evidence of the disposability of the hardened tube liners. Information was also requested about the extent to which the corresponding procedure is already available on the market with external monitoring services.

2.2 System tests

The system tests – testing the suitability for use and refurbishment quality – were carried out in the test set-ups at the IKT's large-scale test facility. The selected liners were used in the test sewers and then subject to comprehensive testing, focussing primarily on the leak tightness and operability of the refurbished sewers.

2.2.1 Test set-ups and damages

For the system tests of the tube liners, lateral pipes with defined damages were produced and covered with a gravel/sand mixture. A clear differentiation was made between lateral pipes in a so-called "standard situation" and a so-called "extreme situation".

The standard situation was used to check the general application possibilities for the tube liners. The extreme situation aimed to touch on the limit areas for using the tube liners.

Altogether 18 standard situations and 18 extreme situations were produced. To do so, three layers of six sewers were produced in the standard situation and three layers of six sewers in the extreme situation, one over the other in the large-scale test facility. The lateral pipes were connected to a main sewer made of vitrified clay 300mm diameter with manholes. The tube liners were installed through access openings. The position of the lateral pipes in the large-scale test facility is shown in a side view in Fig. 1.

To give the technicians optimum access to the access openings, the sewers were produced with differing lengths for the various layers (top layer: approx. 11 m, middle layer: approx. 12 m, bottom layer: approx. 13 m). The tested tube liners were each used in three sewers (one sewer per layer).

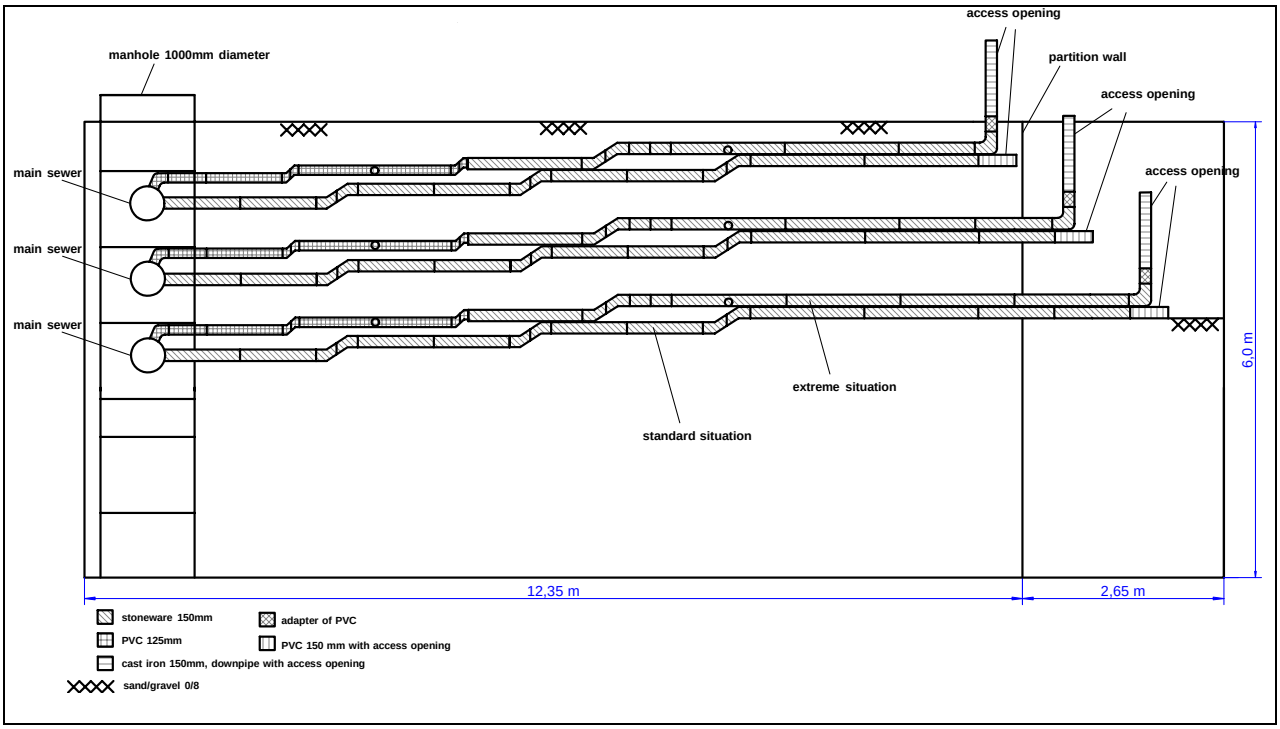


Fig. 1: Position of the lateral pipes in the IKT large-scale testing facility, side view

Test set-up for the standard situation: lateral pipe made of vitrified clay 150mm diameter with 30° and 45° bends; the connection was produced correctly with a connection fitting in the springer of the main pipe; access openings made of PVC 150mm diameter were provided at the end of the vitrified clay sewer to give access for tube liner refurbishment. The sewers were damaged as follows: longitudinal cracks approx. 30 cm long and approx. 2 mm wide at the crown; a transverse crack approx. 10 cm long and approx. 2 mm wide in the base; formation of two fragments measuring approx. 20 cm² respectively 10 cm² in the right-hand springer; a missing piece of pipe measuring approx. 5 x 5 cm in the base.

Test set-up for the extreme situation: lateral pipe made of vitrified clay 150mm diameter with dimensions and material changing to PVC 125mm diameter and 15° and 45° bends; the connection was not produced correctly with a mortar-coated 67° bend between the crown and springer of the main pipe; a side inlet 100mm diameter was indicated in a vitrified clay pipe and a PVC pipe in each case (sealed bore); access openings were provided in downpipes made of cast iron pipes 150mm diameter at the start of the vitrified clay sewer to give access for tube liner refurbishment. These downpipes were connected to the vitrified clay sewer with a 90° vitrified clay bend. The sewers were damaged as follows: a fragment measuring approx. 20 cm² in the base; a longitudinal crack approx. 30 cm long and approx. 2 mm wide in the crown; a transverse crack approx. 20 cm long and approx. 2 mm wide in the case; a missing piece of pipe measuring approx. 5x5 cm in the base, lacking gaskets at all pipe transition points made of PVC.

2.2.2 Refurbishment

When it came to refurbishment of the lateral pipes, the suppliers could choose to have the work performed by their own technicians or recommend a service provider for this purpose. The refurbishment work was commissioned by IKT. The executing companies were free to choose the procedure (preparation including cleaning, actual refurbishment and subsequent work) during refurbishment of the six lateral pipes (3x standard situation, 3x extreme situation). The only stipulation made was that the refurbishment should be carried out from

the access openings to the lateral pipes. No time limit was set for the refurbishment work. The liners used for the work are described below.

- **BendiLiner, EasyLiner GmbH:** the BendiLiner was used to refurbish the extreme situation. The BendiLiner has better bend capability that the SoftLiner by EasyLiner GmbH and is also more flexible at changes in dimensions. It consists of polyester needle felt with an inner foil of PU and is impregnated with epoxy resin EasyPox 3008 (marked on the container). According to the liner supplier, the BendiLiner can be used in nominal widths from 100mm diameter to 150mm diameter.

- **BRAWOLINER - FIX, Karl Otto Braun KG:** the BRAWOLINER - FIX was used to refurbish both the standard situation and the extreme situation. It consists of polyester high-strength fabric with an inner foil of PU and is impregnated with epoxy resin Brawo I (marked on the container) for both situations. According to the liner supplier, BRAWOLINER - FIX can be used in nominal widths from 70mm diameter to 200mm diameter.

- **DrainLiner, epros GmbH:** the DrainLiner was used to refurbish the standard situation. It consists of a polyester needle felt with an inner foil of PVC and is impregnated with epoxy resin Epropox A4/B4 (marked on the container). According to the liner supplier, the DrainLiner can be used in nominal widths from 100mm diameter to 300mm diameter.

- **DrainPlusliner, epros GmbH:** the DrainPlusliner was used to refurbish the extreme situation. The DrainPlusliner is more flexible in changes of dimensions and existing bends than DrainLiner by epros GmbH. It consists of a polyester needle felt with an inner foil of PU; impregnated with epoxy resin Epropox A4/B4 (marked on the container). According to the liner supplier, the DrainPlusliner can be used in nominal widths from 100mm diameter to 300mm diameter.

- **Flex-Liner, Alocit Chemie GmbH :** the Flex-Liner was used to refurbish both the standard situation and the extreme situation. The liner material is a knitted polyester fabric with an inner foil of PVC and is impregnated for both situations with an epoxy resin. Depending on the hardening method, ALOCIT resin 480 and ALOCIT hardener 48.94 (cold hardening) resp. ALOCIT resin 480 and ALOCIT hardener 48.48 (warm hardening) were used (marked on the container). According to the liner supplier, the Flex-Liner can be used in nominal widths from 50mm diameter to 300mm diameter.

- **Konudur Homeliner, MC-Bauchemie Müller GmbH & Co. KG:** the Konudur Homeliner was used to refurbish both the standard situation and the extreme situation. The liner material consists of polyester needle felt with an inner foil of PU and is impregnated for both situations with epoxy resin Konudur 160 PL-XL (marked on container). According to the liner supplier, the Konudur Homeliner can be used in nominal widths from 100mm diameter to 300mm diameter.

- **ProFlex Liner (Prototyp), Vereinigte Filzfabriken AG:** refurbishment of both the standard situation and the extreme situation was carried out with the ProFlex Liner, It consists of meshed felt with an inner foil of PU and is impregnated for both situations with epoxy resin Biresin LS (marked on container). According to the liner supplier, the ProFlex Liner can be used in nominal widths from 70mm diameter to 200mm diameter. The product test was carried out with a prototype of the newly developed liner.

- **SoftLiner, EasyLiner GmbH:** the SoftLiner was used for refurbishment of the standard situation. It consists of a polyester needle felt with an inner foil of PU and is impregnated with epoxy resin EasyPox 3008 (marked on container). According to the liner supplier, the SoftLiner can be used in nominal widths from 70mm diameter to 1200mm diameter.

Refurbishment work to the lateral pipes carried out during the product test was based on the following basic procedure:

- The lateral pipe was cleaned, inspected and measured in length.
- The liner was cut to size according to the dimensions of the lateral pipe. The liner foil was opened at one end and a vacuum pump was connected to support impregnation of the liner.
- The resin components were mixed and the mixture filled into the liner. The tube was impregnated by rolling and at the same time deaerating. Before inversion in the sewer, a lubricant was applied to the liner.
- The liners were inverted with air pressure or water pressure. In nearly all cases, the inversion procedure was carried out with the liner closed at the end. In inversion with the liner open at the end, the liner was inserted in the sewer together with a calibration tube. This calibration tube was then filled with air or water and pressed the liner against the inner wall of the pipe.
- The hardening process was brought about by filling hot water into the liner or by cold hardening under ambient temperature. After hardening, the necessary subsequent work was carried out, e.g. milling the ends of the liners. Insofar as the liners were inserted with one end closed, this was opened after hardening.

2.2.3 Tests and results

2.2.3.1 Testing the operability

Immediately after refurbishment, CCTV was carried out in all lateral pipes. After the refurbished lateral pipes had been removed, they were segmented and then visually inspected again. Any pleats and edges in the liners were recorded in the form of photographs and measured as examples.

The visual inspection of the tube liners resulted in the following basic conclusions for refurbishment of the standard and extreme situation:

- No or only slight pleats were ascertained in the longitudinal direction of straight sections of pipe. Greater pleats were only found to a certain extent in refurbishment of the extreme situation in straight sections of pipe following a transition in the nominal width from 150mm diameter to 125mm diameter.
- As a rule, the tube liners showed pleats in the bends. Longitudinal, transverse and diagonal pleats were seen. The number and height of pleats tended to increase depending on the angle of the bend. In bends of 15° and 30°, fewer pleats were found than in the 45° bends. The pleats in the 45° bends were up to approx. 20 mm high.
- Pleats had also formed in the 90° bends and transitions in nominal width at the extreme situations. Pleating varied depending on the liner being used. In some cases

only slight pleating occurred (< 5 mm), while other liners revealed greater pleating. One liner had pleats of up to approx. 20 mm.

- It clearly emerged that pleating depends greatly on the extensibility of the liner material. Some liner materials stood out because of their particular extensibility, e.g. BRAWOLINER - FIX, DrainPlusliner.

2.2.3.2 Cleaning stresses

The refurbished lateral pipes were subject to stresses of high-pressure cleaning and the use of a spiral machine with various fittings (cross-blade drill, chains) on the inside. These stresses were applied to partial sections of the refurbished lateral pipes so that after dismantling the sewers, unloaded liner samples could be taken for laboratory tests.

Visual inspection of the tube liners after exposure to the cleaning stresses resulted in the following conclusions:

- Neither high-pressure cleaning nor the use of the spiral machine with various fittings caused visible damage to the liner material with hardened resin system.
- The loads imposed by high-pressure cleaning and spiral machine caused clear changes to the inner foil of the liner with the surface of the foil roughened up in numerous places.
- The inner foil of the liners did not work loose from the tube liners to any great extent.

2.2.3.3 Leak tightness tests

The refurbished lateral pipe must be tight immediately after refurbishment and permanently afterwards, i.e. after operational stresses. All tube liners were checked for tightness after completion of the refurbishment work and after being exposed to operational stresses (high-pressure cleaning, mechanical cleaning with spiral machine). Leak tightness tests of the liners were carried out in the large-scale test facility immediately after refurbishment and after exposure to the mechanical stresses, initially as so-called pipe train test as per DIN EN 1610 [9]. After removing the liners, liner samples were tested according to the APS guideline [10] .

Nearly all tube liners were tight following refurbishment during the pipe train test in the large-scale test facility; only one liner was not tight. The liners also fulfilled the tightness criteria of the pipe train test after HP cleaning. But after exposure to mechanical loads with the spiral machine in partial areas of the test sewers, some of the liners had leaks already during the pipe train test. The loads damaged the inner foil of the liners in some cases and the tightness effect of the liners diminished after exposure to these loads, leading to the conclusion that the inner foil played an essential role in fulfilling the tightness criteria for the corresponding liners during the pipe train tests.

This is confirmed by the tightness tests carried out on liner samples according to the APS guideline [10] after removal of the liners. Leaks were found in numerous unloaded samples or samples exposed to HP cleaning and the spiral machine. Altogether 54 unloaded and 126 loaded samples were tested; 25 of the unloaded samples and 63 of the loaded samples were not tight. This corresponds to 46% respectively 50%. It was therefore not possible to ascertain any influence of the mechanical loads on the tightness of the liners. The results of the tightness tests according to the APS guideline show that the liner quality respectively tightness varies across the circumference and length of the liner.

2.2.3.4 Additional tests

Measuring the wall thickness: the results for measuring the wall thickness clearly reveal the differing wall thicknesses of the liners, also showing in some cases considerable fluctuations in wall thickness across the circumference of the liners.

Defining material characteristics (3-point bending test, 24-h creep behaviour, density): The nominal values provided by the suppliers and the values found during the test differ considerably in some cases. But some of the values found in the tests also satisfy the nominal values. The ascertained density was greater than the nominal value in only one liner. The individual values of the ascertained densities confirm the fluctuations in liner characteristics as already ascertained during the tightness tests according to the APS guideline and in measuring the wall thickness.

Cutting open indicated side inlets and visual inspection of the liner to see whether it was coming away from the pipe wall: in nine of ten samples, the liner was found to have formed a firm bond with the old pipe in the area of pipe segment openings, after being cut open. That means that the bond formed by liner and old pipe was scarcely affected by the cutting work. Only the opening cut in one liner revealed that in this case no bond had been formed with the old pipe. It is not clear whether the liner had come away from the wall of the old pipe during the cutting process or whether no bond had been formed in this area already beforehand.

External water pressure test on pipe sections and measuring the annular gap: only two of ten tested pipe segments had no water losses during the external water pressure test. These two pipe segments did not show any effects of the resulting pressure, e.g. bulging of the liner or inner foil. As a rule, the water penetrated in the annular gaps respectively capillaries between the outer surface of the liner and the inner surface of the pipe and emerged again at the surfaces where the samples had been cut. Water only also infiltrated through the liner wall in just one sample.

2.3 Construction site investigations

The use of nearly all tested tube liners was observed in existing lateral pipes on building sites[1]. To summarise it can be said that the installation of the tube liners was suitable for practical use on the building sites. The encountered technical problems were solved on site in an appropriate period of time. The machinery could be brought to the corresponding refurbishment starting points without any difficulties, e.g. access openings in basement rooms, access manholes on the plots. It was possible to insert the liners even in confined space, e.g. narrow pipe ditches and small access openings.

[1] This was not possible only in the case of the DrainLiner because at this point in time, the liner had not been introduced into regular use by the affected sewage network operators, nor could the liner supplier name any building sites in response to the IKT's enquiry. But the procedures involved in installation correspond basically to those for the DrainPlusliner so that adequate site impressions were obtained.

3 Assessment of the tube liners

The system tests are assessed on the basis of use of the tube liners in the large-scale test facility, differentiating between the two application cases "standard situation" and "extreme situation". Test marks are therefore given separately for the corresponding tube liners according to the focal issues *quality assurance of the liner suppliers* and *system tests* for application case I "standard situation" and II "extreme situation".

3.1 Assessment point "quality assurance of the liner suppliers"

The assessment point *"quality assurance of the liner suppliers"* accounts for 20% of the corresponding test mark. It includes the five assessment cases stated in the following table with the weighting shown there. The cases are assessed with the criterion "yes/no". "Yes" means that the corresponding quality assurance was verified to the full. "No" indicates that a corresponding verification was missing. The results are depicted by a linear function based on grades, whereby 100% stands for the grade "very good (1.0)" and 0% for the grade "inadequate (6.0)".

Table 1: Assessment scheme for the test aspect "Quality assurance of the liner suppliers"

Assessment cases	Criteria	Weighting
DIBt certification	yes/no	50 %
Test certificate for environment compatibility	yes/no	20 %
Procedure manual and training courses	yes/no	10 %
External monitoring	yes/no	10 %
Evidence of disposability	yes/no	10 %

3.2 Assessment point "system tests"

The assessment points *"system test standard situation (application case I)"* and *"system test extreme situation (application case II)"* account for 80% of the corresponding test mark. Grades from "very good (1.0)" to "inadequate (6.0)" are given for both assessment points, which include the assessment cases "refurbishment results", "HP cleaning" and "mechanical cleaning". The assessment case "refurbishment results" is assessed according to the criteria "tightness" and "operability", and the assessment cases "HP cleaning" and "mechanical cleaning" according to the criterion "leak tightness".

The criterion "operability (visual condition)" indicates whether refurbishment has been able to restore reliable disposal. The assessment was made by the participating sewage network operators awarding points on the basis of the photo documentation and measuring results, the CCTV inspection and the exemplary examination of samples taken from the systems. A minimum of 0 and maximum of 100 points were awarded, whereby 100 points stand for visually perfect refurbishment results (very good/1.0) and 0 points for visually unacceptable refurbishment results (inadequate/6.0). All assessment results were averaged by arithmetic means for the group of sewage network operators and the marks were depicted by a linear function.

As far as the criterion "leak tightness" is concerned, the results were based on IKT's laboratory tests on liner samples according to the APS guidelines. The results of the tightness tests were shown as a percentage and the marks were depicted by a linear function. The results of the "pipe train test" in the large-scale test facility were not included in the test marks. This was because leak tightness in the case of the "pipe train test" can also

have been due to the inner foil of the liner. In the opinion of the participating sewage network operators, the liner material with resin must be tight even without the inner foil, which functions primarily as installation aid.

The assessment scheme for the *"system test standard situation (application case I)"* and *"system test extreme situation (application case II)"* is shown in the following table as weighted by the sewage network operators.

Table 2: Assessment scheme for the test aspect "*System tests"*

Application cases	Assessment cases	Criteria
Standard situation	Refurbishment results (60 %)	Tightness (60 %)
		Operability(40 %)
	HP cleaning (20%)	Tightness (100%)
	Mechanical cleaning (20%)	Tightness (100%)
Extreme situation	Refurbishment results (60 %)	Tightness (60 %)
		Operability(40 %)
	HP cleaning (20%)	Tightness (100%)
	Mechanical cleaning (20%)	Tightness (100%)

4 Test marks and overall results

The test marks for the tube liners for each particular application case (I: standard situation, II: extreme situation) are made up of the assessment points *"quality assurance of the liner suppliers (20%)"* and *"system test (80%)".* The assessment points *"system test standard situation"* and *"quality assurance of the liner suppliers"* respectively *"system test extreme situation"* and *"quality assurance of the liner suppliers"* therefore always resulted in two test marks.

Tube liners used only for one of the two application cases – standard or extreme situation – only receive just one test mark. Insofar as tube liners were not used for one or both application cases, these are not assessed for the corresponding case or cases.

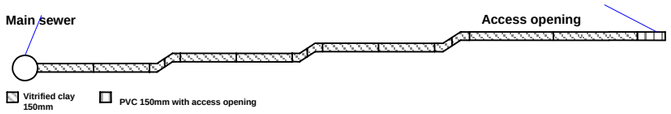
As a result, the SoftLiner (EasyLiner GmbH) and the DrainLiner (epros GmbH) are given a test mark for the application case "standard situation" but are NOT ASSESSED for the application case "extreme situation". By contrast, the BendiLiner (EasyLiner GmbH) and the DrainPlusliner (epros GmbH) are given a test mark for the application case "extreme situation", but are NOT ASSESSED for the application case "standard situation". The Mr. PIPE-Liner (Mr. PIPE GmbH) and the Insituform-Liner (Insituform GmbH) are NOT ASSESSED for both application cases "standard situation" and "extreme situation". Both liners were to be used for the test, but the corresponding suppliers declined to participate (see corresponding letters in Annex I and Annex II).

The test marks for the tested tube liners are shown below. In addition, the liners which were not used for the corresponding application cases are also featured with a corresponding explanation. The tables also summarise the results of the site tests, additional information and the recognised potential for improving the individual tube liners.

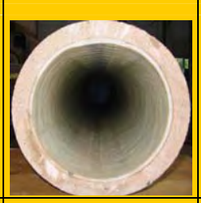
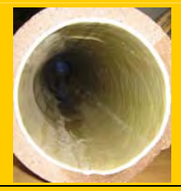
Table 3: Results of the IKT-Product-Test „Tube Liners for Lateral Pipes“ in the standard situation

IKT-Product-Test „Tube Liners for Lateral Pipes“

Standard situation[1]:



Refurbishment of three vitrified clay lateral pipes 150mm diameter; correct connection with a connection fitting in the springer of the main pipe; inversion through access openings at the start of the vitrified clay sewer; vertical bends: 45° and 30°; applied damage: longitudinal cracks, transverse cracks, fragmenting, missing pipe pieces.

Liner supplier		KOB KG	epros GmbH	MC Bauchemie Müller GmbH & Co. KG	EasyLiner GmbH	ALOCIT Chemie GmbH	VFG AG	epros GmbH	EasyLiner GmbH	Mr. PIPE GmbH	Insituform Rohrsanierungs-techniken GmbH
Tube liner		BRAWOLINER - FIX	DrainLiner	Konudur Homeliner	SoftLiner	Flex-Liner	ProFlex Liner (Prototyp)	DrainPlusliner	BendiLiner	Mr. PIPE-Liner	Insituform-Liner
										-	-
Basic material		Polyester high-strength fabric with PU foil	Polyester needle felt with PVC foil	Polyester needle felt with PU foil	Polyester needle felt with PU foil	Knitted polyester fabric with PVC foil	Meshed felt with PU foil	-	-	-	-
Resin system		Brawo I	EPROPOX VIS A4/B4	Konudur 160 PL-XL	EasyPox 3008	ALOCIT A 480, B 48.48 resp. 48.94[8]	Biresin LS	-	-	-	-
IKT test mark: standard situation		GOOD (1.6)	SATISFACTORY (2.6)	SATISFACTORY (2.8)	SATISFACTORY (3.3)	ADEQUATE (4.2)	ADEQUATE (4.4)	NOT ASSESSED	NOT ASSESSED	NOT ASSESSED	NOT ASSESSED
System test (weighting 80%)		good (1.6)	good (2.3)	good (2.1)	satisfactory (3.0)	adequate (3.7)	adequate (4.0)				
Refurbishment result (60%)	Operability[2] (40%)	1.7	2.4	2.2	2.9	2.6	2.1				
	Tightness[3] (60%)	1.8	2.7	1.8	3.5	3.5	4.3				
Tightness after HP cleaning[3] (20%)		1.0	1.0	2.7	1.0	4.3	4.3				
Tightness after mechanical cleaning[3] (20%)		1.6	2.7	2.1	4.3	4.9	5.4				
Quality assurance (weighting 20%)		very good (1.5)	adequate (4.0)	poor (5.5)	adequate (4.5)	inadequate (6.0)	inadequate (6.0)				
DIBt certification[4] (50%)		yes	no	no	no	no	no				
Environment compatibility test certificate submitted for the resin[4] (20%)		yes[5]	yes	no	yes[7]	no	no				
Procedure manual and training courses[4] (10%)		yes	yes	no	no	no	no				
External monitoring[4] (10%)		yes	yes	yes	yes	no	no				
Evidence of disposability[4] (10%)		no	no	no	no	no	no				
Construction site investigation		practice-orientated installation	not carried out	practice-orientated installation	practice-orientated installation	practice-orientated installation	practice-orientated installation				
Additional information: available for		70mm to 200mm	100mm to 300mm	100mm to 300mm	70mm to 1200mm	50mm to 300mm	70mm to 200mm				
Recommended improvements		Reduce fluctuations in the liner properties	Reduce fluctuations in the liner properties; extend DIBt certification to include the used resin system	Reduce fluctuations in the liner properties; improve quality assurance	Reduce fluctuations in the liner properties; improve tightness and quality assurance	Reduce fluctuations in the liner properties; improve tightness and quality assurance	Reduce fluctuations in the liner properties; improve tightness and quality assurance	• Tube liner was not used • Reason: supplier decided to use the DrainLiner for refurbishment of the standard situation	• Tube liner was not used • Reason: supplier decided to use the SoftLiner for refurbishment of the standard situation	• Participation declined • Supplier's reason: quality already verified to an adequate extent by other documents (including DIBt certification) • Complete letter declining participation dated 27.01.2005 included in Annex I of the final report	• Participation declined • Supplier's reason: test conditions outside the specifications of the Insituform-Liner • Complete letter declining participation dated 14.02.2005 in Annex II of the final report

1 "Standard situation" refers to the geometry of the lateral pipe.
2 Assessment of the operability through visual inspection of the refurbished standard situation by the sewage network operators: 100 points = 1.0 to 0 points = 6.0; marks depicted by a linear function.
3 Assessment: 100% tightness tests passed according to APS guideline = 1.0 to 0% tightness tests passed according to APS guideline = 6.0; marks depicted by a linear function.
4 Assessment: present = yes, not present = no; certifications/certificates/verifications must be valid for the materials used in the test.
5 According to the DIBt certification, a PE protective tube is to be used between the liner impregnated with resin and the pipe being refurbished when using the refurbishment method in areas saturated with ground water.
6 The liner was not used by the participating sewage network operators at the point in time of the site tests; the liner supplier could not name a site either. The installation procedure corresponds basically to that used for the DrainPlusliner.
7 Test certificate of the Hygiene Institute of the Ruhr area dated 1 August 2002: "Given the clear smell and taste contamination of the test water, it is advisable as a precaution to refrain from using in direct drinking water catchment areas (protection zone I) and in protection zone II"..." In our opinion [there] are no objections to using the material "EasyPox" in areas with groundwater contact, as long as these are above the saturated zone and outside drinking water protection zone II".
8 Both B-components (hardeners) 48.48 resp. 48.94 were available and were used.

Assessment key for the test results: very good = 1.0 – 1.5, good = 1.6 – 2.5, satisfactory = 2.6 – 3.5, adequate = 3.6 – 4.5, poor = 4.6 – 5.5, inadequate = 5.6 – 6.0.

The test report can be downloaded under www.ikt.de (in German)

IKT - Institute for Underground Infrastructure
45886 Gelsenkirchen
Exterbruch 1

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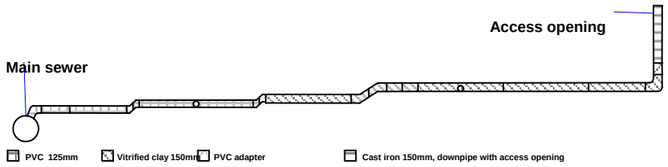
http://www.ikt.de

Table 4: Results of the IKT-Product-Test „Tube Liners for Lateral Pipes“ in the extreme situation

IKT-Product-Test „Tube Liners for Lateral Pipes“

Extreme situation[1]:



Refurbishment of three lateral pipes of vitrified clay 150mm diameter with change in dimension and material to PVC 125mm diameter; connection between crown and springer of the main sewer not correctly executed with mortar coated 67° bend; inversion through access openings in the downpipes made of cast iron 150mm diameter; vertical bends: 90°, 45° and 30°; horizontal bends: 15°; applied damage: longitudinal cracks, transverse cracks, fragmenting, lacking pipe pieces, indicated side inlets, lacking gaskets.

Liner supplier	KOB KG	MC Bauchemie Müller GmbH & Co. KG	epros GmbH	EasyLiner GmbH	VFG AG	ALOCIT Chemie GmbH	epros GmbH	EasyLiner GmbH	Mr. PIPE GmbH	Insituform Rohrsanierungs-techniken GmbH
Tube liner	BRAWOLINER - FIX	Konudur Homeliner	DrainPlusliner	BendiLiner	ProFlex Liner (Prototyp)	Flex-Liner	DrainLiner	SoftLiner	Mr. PIPE-Liner	Insituform-Liner
									-	-
Basic material	Polyester high-strength fabric with PU foil	Polyester needle felt with PU foil	Polyester needle felt with PU foil	Polyester needle felt with PU foil	Meshed felt with PU foil	Knitted polyester fabric with PVC foil	-	-	-	-
Resin system	Brawo I	Konudur 160 PL-XL	EPROPOX VIS A4/B4	EasyPox 3008	Biresin LS	ALOCIT A 480, B 48.48 resp. 48.94[5]	-	-	-	-
IKT test mark: extreme situation	VERY GOOD (1.3)	SATISFACTORY (3.2)	ADEQUATE (3.9)	ADEQUATE (4.1)	POOR (4.6)	POOR (5.1)	NOT ASSESSED	NOT ASSESSED	NOT ASSESSED	NOT ASSESSED
System test (weighting 80%)	very good (1.2)	satisfactory (2.6)	adequate (3.9)	adequate (4.0)	adequate (4.3)	poor (4.9)				
Refurbishment result (60%) – Operability[2] (40%)	1.9	2.6	1.7	2.4	2.9	3.5				
Refurbishment result (60%) – Tightness[3] (60%)	1.0	4.3	4.3	6.0	6.0	6.0				
Tightness after HP cleaning[3] (20%)	1.0	1.0	4.3	1.0	1.0	4.3				
Tightness after mechanical cleaning[3] (20%)	1.0	1.0	5.2	5.2	6.0	5.2				
Quality assurance (weighting 20%)	very good (1.5)	poor (5.5)	adequate (4.0)	adequate (4.5)	inadequate (6.0)	inadequate (6.0)				
DIBt certification[4] (50%)	yes	no	no	no	no	no				
Environment compatibility test certificate submitted for the resin[4] (20%)	yes[6]	no	yes	yes[7]	no	no	• Tube liner was not used • Reason: supplier decided to use the DrainPlusliner for refurbishment of the extreme situation	• Tube liner was not used • Reason: supplier decided to use the BendiLiner for refurbishment of the extreme situation	• Participation declined • Supplier's reason: quality already verified to an adequate extent by other documents (including DIBt certification • Complete letter declining participation dated 27.01.2005 included in Annex I of the final report	• Participation declined • Supplier's reason: test conditions outside the specifications of the Insituform-Liner • Complete letter declining participation dated 14.02.2005 in Annex II of the final report
Procedure manual and training courses[4] (10%)	yes	no	yes	no	no	no				
External monitoring[4] (10%)	yes	yes	yes	yes	no	no				
Evidence of disposability[4] (10%)	no	no	no	no	no	no				
Construction site investigation	practice-orientated installation	practice-orientated installation	practice-orientated installation	practice-orientated installation	practice-orientated installation	practice-orientated installation				
Additional information: available for	70mm to 200mm	100mm to 300mm	100mm to 300mm	100mm to 150mm	70mm to 200mm	50mm to 300mm				
Recommended improvements	Reduce fluctuations in the liner properties	Reduce fluctuations in the liner properties; improve quality assurance	Reduce fluctuations in the liner properties; improve tightness; extend DIBt certification to include the used resin system	Reduce fluctuations in the liner properties; improve tightness and quality assurance	Reduce fluctuations in the liner properties; improve tightness and quality assurance	Reduce fluctuations in the liner properties; improve tightness and quality assurance				

1 "Extreme situation" refers to the geometry of the lateral pipe.
2 Assessment of the operability through visual inspection of the refurbished standard situation by the sewage network operators: 100 points = 1.0 to 0 points = 6.0; marks depicted by a linear function.
3 Assessment: 100% tightness tests passed according to APS guideline = 1.0 to 0% tightness tests passed according to APS guideline = 6.0; marks depicted by a linear function.
4 Assessment: present = yes, not present = no; certifications/certificates/verifications must be valid for the materials used in the test.
5 Both B-components (hardeners) 48.48 resp. 48.94 were available and were used.
6 According to the DIBt certification, a PE protective tube is to be used between the liner impregnated with resin and the pipe being refurbished when using the refurbishment method in areas saturated with ground water.
7 Test certificate of the Hygiene Institute of the Ruhr area dated 1 August 2002: "Given the clear smell and taste contamination of the test water, it is advisable as a precaution to refrain from using in direct drinking water catchment areas (protection zone I) and in protection zone II"..." In our opinion [there] are no objections to using the material "EasyPox" in areas with groundwater contact, as long as these are above the saturated zone and outside drinking water protection zone II".

Assessment key for the test results: very good = 1.0 – 1.5, good = 1.6 – 2.5, satisfactory = 2.6 – 3.5, adequate = 3.6 – 4.5, poor = 4.6 – 5.5, inadequate = 5.6 – 6.0.

The test report can be downloaded under www.ikt.de (in German)

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http://www.ikt.de

5 Conclusions

Foil makes the Tube Liner tight

A comparison of the results from the so-called pipe train test (acceptance test as per DIN EN 1610) with those from the APS test show that in many cases, it is the inner foil which makes the liner tight. If this foil is removed in places – as is normal with the APS test – then the tightness disappears as well. This is demonstrated by numerous leaking liner samples.

Quality fluctuations

All tube liners showed fluctuations in the liner properties. These fluctuations were ascertained both across the circumference of the liners, e.g. in measuring wall thickness, and also along the liner length, e.g. in measuring the density. The results of the tightness test according to the APS guideline underline the quality fluctuations of the liners. In some cases, the spread in the results even leads to apparent contradictions in the test results. For example, these fluctuations meant that the BRAWOLINER - FIX produced better results for the "system test extreme situation" (grade "very good", 1.2) than for the "system test standard situation" (grade "good", 1.6).

Operating loads with negligible influence

The loads resulting from HP cleaning and mechanical cleaning (spiral machine with various fittings) applied during the test showed no obvious influence on liner quality. The results of the tightness tests were apparently dominated by the spread in material properties. As a rule, the applied loads only roughened up or partly damaged the inner foil. No changes were found in the actual material of the liner.

Conflict of aims between operability and tightness

Nearly all tube liners in the test produced better results for operability than for tightness. Prerequisite for good operability of the refurbished lateral pipe is that the liner only shows slight if any pleats and edges after refurbishment. To achieve this, the liner material must be appropriately flexible in the bends. But this flexibility can be opposed to the tightness of the material. This was particularly clear in the test when the liner suppliers used different tube liners for refurbishment of the standard and extreme situations. The "DrainPlusliner" and "BendiLiner" products used only for refurbishment in the extreme situation showed far fewer pleats in the bends than the "DrainLiner" or "SoftLiner" used for refurbishment of the standard situation, and yet their poorer performance in terms of tightness resulted in an overall less satisfactory test result.

Quality assurance in preparation

Only one provider offered convincing quality assurance with the grade "very good (1.5)". Most suppliers supplied incomplete documents if any at all. In some cases the documents referred to other materials than those used in the test. But many suppliers indicated that they were currently improving the quality assurance of their products. For example, three suppliers have applied for certification of their tube liners by the Deutsche Institut für Bautechnik (DIBt).

Practice-oriented installation

The site tests confirmed the impressions gained during installation of the tube liners in IKT's large-scale test facility. The used procedures are also suitable for installation of the tube liners under practical conditions (confined space, time pressure) and are therefore also fundamentally suitable for refurbishment of lateral pipes. However, random tightness tests carried out on liner samples once again revealed differences in quality across the length or circumference of the liners. For many liners, the question therefore arises whether it is at all

possible for the tightness criteria stipulated by the sewage network operators to be fulfilled on-site.

Conclusion

The IKT-Product-Test „Tube Liners for Lateral Pipes“ assesses eight tube liners for the refurbishment of lateral pipes.

The test results show that the liner suppliers still have a lot to do. Although the test confirmed that the tube liners can fundamentally be used even for sewers with many bends with the resulting refurbishment restoring the operability of the lateral pipe, most of the tube liners rarely fulfilled the tightness requirements made by the sewage network operators. In addition, the performed tests revealed considerable fluctuations in liner quality both across the circumference and along the length of the liners. There are also gaps in the quality assurance procedures, which in most cases are still in the preparatory stages.

The IKT-Product-Test „Tube Liners for Lateral Pipes“ is the fourth IKT-Product-Test (cf. IKT-Product-Tests "House Connection Fittings" [6], "Repair procedure for connection fittings" [7] and "Inspection Systems for Domestic Sewer Networks" [8]). The eager participation of sewage network operators in the IKT-Product-Tests underlines their practical significance. The way the test results are accepted in the trade also shows what a demand there is for comparative product tests in sewage technology. The IKT product tests support the "circle of product improvement" (cf. [11]) and the development of improved or even new products (cf. [12]). The overall aim in future will remain that of improving the quality of the offered products in the interests of the sewage network operators.

6 Annex

Annex I:

Declining letter from Mr. Pipe GmbH

Annex II:

Declining letter from Insituform Rohrsanierungstechniken GmbH

Annex I:

- Declining letter from Mr. Pipe GmbH (3 of 3 pages) and Translation-

Mr. PIPE GmbH Postfach 1741 94457 Deggendorf

IKT – Institut für
Unterirdische Infrastruktur
Herr Gunter Kaltenhäuser
Exterbruch 1

45886 Gelsenkirchen

Eingang IKT
28. JAN. 2005

Schwaigerbreite 17
94469 Deggendorf
Telefon 0991/330410
Telefax 0991/330429
info@mrpipe.de
www.mrpipe.de

Ihr Zeichen	Ihre Nachricht vom	Telefon-Durchwahl	Unser Zeichen	Deggendorf
		0991 33 04 10	Sp/Ee	27.01.2005

IKT-Warentest „Schlauchliner für Anschlusskanäle"

Sehr geehrter Herr Kaltenhäuser,

wie Sie ja bereits wissen, besitzt unser Mr.PIPE-Liner eine DIBt-Zulassung (Z-42.3-364). Im Rahmen dieser Zulassung wurden bereits alle nur erdenklich möglichen Qualitätskriterien über einen langen Zeitraum überprüft. Die ständige Kontrolle unserer Arbeiten erfolgt durch den Güteschutz Kanalbau (Gütezeichen S 29.06). Bis heute haben wir sehr viel in unser Produkt, das Personal, die Anlagentechnik und dessen Zulassungen investiert. Wir sind der Meinung, dass die aufgeführten Punkte eine ausreichende Qualifikation darstellen und sehen daher von einer Teilnahme an Ihrem Warentest ab.

Zur Vervollständigung Ihrer Unterlagen haben wir diesem Schreiben Kopien der ersten Seite unserer DIBt-Zulassung sowie der Urkunde des Güteschutz Kanalbaus beigefügt. Wir danken für Ihr Verständnis.

Freundliche Grüße

Mr. PIPE
Rohr- und Kanalsanierungstechnik GmbH
i.A. Elke Ertl
i.A. Philipp Scholz

Mr. PIPE Rohr- und Kanalsanierungstechnik GmbH
Sitz: Deggendorf
Registergericht:
Deggendorf, HRB 1834
USt.-ID-Nr.: DE 186700371
Steuer-Nr.: 162/132/80035
Geschäftsführer: Hubert Ruderer

Bankverbindung
Dresdner Bank AG
Nr. 738174800 (BLZ 74180009)
Swift-Code: DRES DE FF 7

Bundesweit zum Ortstarif erreichbar: 0180/1677473

- Appendix 1 to the declining letter from Mr. Pipe GmbH -

DEUTSCHES INSTITUT FÜR BAUTECHNIK

Anstalt des öffentlichen Rechts

10829 Berlin, 17. August 2004
Kolonnenstraße 30 L
Telefon: 030 78730-276
Telefax: 030 78730-320
GeschZ.: III 22-1.42.3-30/04

Bescheid

über
die Änderung
der allgemeinen bauaufsichtlichen Zulassung vom 27. April 2004

Zulassungsnummer: Z-42.3-364

Antragsteller: Mr. PIPE GmbH
Schwaigerbreite 17
94469 Deggendorf

Zulassungsgegenstand: Schlauchliningverfahren mit der Bezeichnung "Mr. PIPE-Liner" zur Sanierung von erdverlegten schadhaften Abwasserleitungen in den Nennweiten DN 100 bis DN 300

Geltungsdauer bis: 31. Mai 2009

Dieser Bescheid ändert die allgemeine bauaufsichtliche Zulassung Nr. Z-42.3-364 vom 27. April 2004. Dieser Bescheid umfasst zwei Seiten und eine Anlage. Er gilt nur in Verbindung mit der oben genannten allgemeinen bauaufsichtlichen Zulassung und darf nur zusammen mit dieser verwendet werden.

Deutsches Institut für Bautechnik 23

30481.04

- Appendix 2 to the declining letter from Mr. Pipe GmbH -

GÜTESCHUTZ KANALBAU

GÜTEGEMEINSCHAFT
HERSTELLUNG UND INSTANDHALTUNG
VON ABWASSERLEITUNGEN UND KANÄLEN E.V.

Verleihungs-Urkunde

Die Gütegemeinschaft Herstellung und Instandhaltung von Abwasserleitungen und -kanälen e.V. verleiht hiermit aufgrund des von ihrem Güteausschuss vorliegenden Prüfberichtes der Firma

Mr. Pipe Rohr- und Kanalsanierungstechnik GmbH
94469 Deggendorf
Mitgl.-Nr.: 2533

das vom RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V. anerkannte und durch Eintragung beim Deutschen Patent- und Markenamt als Kollektivmarke geschützte Gütezeichen für Herstellung und Instandhaltung von Abwasserleitungen und -kanälen.

GÜTEZEICHEN
RAL
KANALBAU

S29.06;I

Die Verleihung der Beurteilungsgruppe S gilt für die fachgerechte Handhabung und gütegesicherte Ausführung der Sanierung mit dem Sanierungsverfahren S29.06 – Mr. Pipe Hausanschlussliner.

Die Benutzung des Gütezeichens ist nur in Verbindung mit dem unter dem Gütezeichen dargestellten Zusatz erlaubt.

Bad Honnef, den 15.12.2004

Gütegemeinschaft Herstellung und Instandhaltung
von Abwasserleitungen und -kanälen e.V.

Dipl.-Ing., Dipl.-Kfm. C.-F. Thymian
(Vorsitzender)

Dr.-Ing. H. Friede
(Geschäftsführer)

- Translation of the declining letter from Mr. Pipe GmbH -

IKT Product Test "Tube Liners for Connection Sewers"

Dear Mr. Kaltenhäuser,

As you already know, our Mr.PIPE-Liner already has DIBt certification (Z-42.3.364). During this certification, all possibly conceivable quality criteria were tested over a long period of time. On-going audits of our work are carried out by "Güteschutz Kanalbau" (quality marking S 29.06). Up to the present day, we have invested a great amount in our product, human resources, equipment and corresponding certification. We are of the opinion that these points constitute adequate qualification and therefore refrain from taking part in your product test.

To supplement your documents, please find enclosed with this letter copies of the first page of our DIBt certification and the certificate issued by "Güteschutz Kanalbau". Many thanks for your understanding.

Yours sincerely

Mr. PIPE
Rohr- und Kanalsanierungstechnik GmbH
/signature/

pp. Philipp Scholz

Annex II:

- Declining letter from Insituform Rohrsanierungstechniken GmbH -

Insituform
Rohrsanierungstechniken GmbH

Hauptverwaltung

Insituform® — Sulzbacher Straße 47 — D-90552 Röthenbach/Pegnitz

IKT Institut für Unterirdische Infrastruktur
Herr Kaltenhäuser
Exterbruch 1

45886 Gelsenkirchen

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Sulzbacher Straße 47 — D-90552 Röthenbach/Pegnitz
Tel +49 (0) 911/9 57 73 - 0 — Fax +49 (0) 911/9 57 73 - 33

Eingang IKT
15. FEB. 2005

Ihr Zeichen:	Ihre Nachricht vom:	Unser Zeichen:	Sachbearbeiter:	Datum:
		jz/si	Herr Zinnecker	14.02.2005

Ihr Schreiben vom 03.02.2005 Schlauchliner für Anschlusskanäle

Sehr geehrter Herr Kaltenhäuser,

wie bereits mit Herrn Homann am 11.02.2005 in Oldenburg und Ihnen am heutigen Tage telefonisch besprochen, möchten wir die Teilnahme an dem IKT-Warentest „Schlauchliner für Anschlusskanäle" absagen.

Für die Sanierung von Anschlussleitungen wird von uns der Insituform-Liner eingesetzt. Dieser Liner ist nicht als „bogengängiger" Liner entwickelt, es können jedoch einzelne Bögen durchfahren werden. Mit dem Insituform-Liner werden Hausanschlüsse von Revisionsschächten oder –öffnungen aus bis zur Hauptleitung saniert, diese Sanierungstechnik wird bei Insituform als Schnellhärtetechnik definiert. Hierbei werden die Liner vor Ort unter fabrikähnlichen, witterungsunabhängigen Bedingungen imprägniert. Mit dieser Technik werden nicht nur Anschlussleitungen saniert sondern auch kurze Einzelhaltungen bis zu einer Länge von 60 m. Im letzten Jahr wurden ca. 12 000 m mit dieser Technik saniert. Vorhandene einzelne Bögen können hierbei durchfahren werden.

Nach der Prüfung der anliegenden Aufzeichnung des Leitungsverlaufes sind wir der Meinung, dass der Einsatz außerhalb der Spezifikationen des Insituform-Liners liegt. Vergleichbare Leitungsverläufe werden von Seiten Insituform durch bereits im Test enthaltene Liner oder durch Subunternehmer saniert.

Gern sind wir aber zu einem Test der Insituform-Schnellhärtetechnik bereit, welches eventuell im Zuge des Tests der Ferngesteuerten Anschlusssanierung erfolgen kann.

Bei Rückfragen stehen wir Ihnen gern zur Verfügung.

Mit freundlichen Grüßen verbleibt
Insituform
Rohrsanierungstechniken GmbH
Dipl.-Ing. Jürgen Zinnecker
Technik & Entwicklung

K:\TuE\IKT - Institut f. unterird. Infrastruktur\Warentest Leitungssanierung\Absage Leitungssanierg.doc
Seite 1

- Translation of the declining letter from Insituform Rohrsanierungstechniken GmbH -

Your letter dated 3 February 2005, tube liners for connection sewers

Dear Mr. Kaltenhäuser,

As already discussed with Mr. Homann on 22 February 2005 in Oldenburg and with you today on the phone, we would like to refrain from participating in the IKT product test "Tube liners for lateral pipes".

We use the Insituform-Liner to refurbish lateral pipes. This liner has not been developed as "bend-compatible" liner, although it passes through single bends. The Insituform-Liner is used to refurbish house connections from access manholes or openings through to the main pipe; this refurbishment technology is defined at Insituform as fast-hardening technology. The liner is impregnated on site under conditions similar to the factory, regardless of the weather. This technology refurbishes not only connection pipes but also short individual reach lengths up to a length of 60 m. Last year approx. 12,000 m were refurbished with this technology. The system can be used to pass through single existing bends.

After reviewing the drawing of the pipeline section sent to us, we are of the opinion that this particular application is not within the specifications of the Insituform liner. To refurbish pipeline sections of this kind, Insituform uses liners already contained in the test or reverts to subcontractors.

However, we would be quite willing for the Insituform fast-hardening technology to be tested, possibly as part of the test for remote-controlled connection refurbishment.

Please do not hesitate to contact us with any queries.

Yours sincerely,

/signature/

Insituform
Rohrsanierungstechniken GmbH
Dipl.-Ing. Jürgen Zinnecker
Technology and Development

7 Literature

[1] Berger, C.; Lohaus, J.: Zustand der Kanalisation in Deutschland, Ergebnisse der DWA-Umfrage, Hennef, 2004.

[2] Strafgesetzbuch (StGB) vom 15. Mai 1871 in der Fassung der Bekanntmachung vom 13. November 1998, zuletzt geändert durch Art. 1 G am 22. August 2002, hier §§324 ff.

[3] Gesetz zur Ordnung des Wasserhaushalts (Wasserhaushaltsgesetz - WHG), vom 27. Juli 1957 in der Neufassung der Bekanntmachung vom 12. November 1996.

[4] Bauordnung für das Land Nordrhein-Westfalen (BauO NW); in der Fassung und Bekanntmachung vom 07. März 1995, zuletzt geändert am 24. Oktober 1998.

[5] Verordnung zur Selbstüberwachung von Kanalisationen und Einleitung von Abwasser aus Kanalisationen im Mischsystem und im Trennsystem (Selbstüberwachungsverordnung Kanal - SüwV Kan); Gesetz- und Verordnungsblatt für das Land NRW, Nr. 49: S. 64- 67; Düsseldorf 1995.

[6] Bosseler, B.; Kaltenhäuser, G.; Puhl, R.: IKT-Warentest „Hausanschlussstutzen“; IKT - Institut für Unterirdische Infrastruktur; Gelsenkirchen, Juni 2001; download unter www.ikt.de.

[7] Bosseler, B.; Kaltenhäuser, G.: IKT-Warentest „Reparaturverfahren für Anschlussstutzen“; IKT - Institut für Unterirdische Infrastruktur; Gelsenkirchen, Juni 2004; download unter www.ikt.de.

[8] Bosseler, B.; Kaltenhäuser, G.: IKT-Warentest „Inspektionssysteme für Grundstücksentwässerungsnetze“; IKT - Institut für Unterirdische Infrastruktur; Gelsenkirchen, September 2005; download unter www.ikt.de.

[9] DIN EN 1610: Verlegung und Prüfung von Abwasserleitungen und -kanälen; Beuth-Verlag, Oktober 1997.

[10] APS-Prüfrichtlinie erschienen im IKT-eNewsletter „Schlauchliner: Dicht oder doch nicht dicht?“; September 2004.

[11] Homann, D.; Kaltenhäuser, G.: IKT-Warentest „Flexoset-Anschlusselement B“ – Nachtest zum IKT-Warentest „Hausanschluss-Stutzen“; IKT - Institut für Unterirdische Infrastruktur; Gelsenkirchen, Juni 2003; download unter www.ikt.de.

[12] Kaltenhäuser, G.: IKT-Warentest „Janssen-Verpresssystem mit Mörtel“ - Nachtest zum IKT-Warentest „Reparaturverfahren für Anschlussstutzen“; IKT - Institut für Unterirdische Infrastruktur (laufender Test, geplanter Abschluss Ende 2005).