IKT-LinerReport 2006

Cured-In-Place Pipes: Glass Clearly Ahead?

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Is the material the only important factor in cured-in-place pipe rehabilitation? What quality standards do installers (contractors) achieve, and with what types of liner? The independent and neutral IKT Test Center for Pipe Liners now submits, for the third time, its IKT-LinerReport. This paints for 2006 a differentiated picture based on test results obtained from more than one thousand on-site samples.

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Industry experts are increasingly questioning which are the best liner types and the best pipe lining methods. Two „families“ of technologies compete in the marketplace: Tube liners employing glass-fiber, and those employing needle-felt, as the support material.

It is no surprise that the various manufacturers emphasize only the benefits of their own systems. But what are the facts? What results are actually achieved on the building site?

The IKT-LinerReport 2006 provides answers to these questions on the basis of laboratory results obtained by the independent and neutral IKT Test Center for Pipe Liners.

Material and Man

Pipe liners are, in principle, new pipes produced from ultra-modern composite materials. They are manufactured and cured at the construction site, however. Unlike pipes produced in a factory, these onsite cured pipeliners are subject to adverse conditions which frequently prevail on such sites. These conditions will differ significantly from location to location but the correct installation and cure must, nonetheless, be mastered at each location to achieve expected results and success.

This necessitates the highest qualities in the raw support materials and resins used. Only a highly experienced and well coordinated team, fully in control of the complex installation and curing processes, can produce from the raw materials, a tight fitting, structural and leakproof liner which will stand up to several decades of pipeliner service.

Data-base

The data for all installation companies for whom the IKT has performed at least twenty-five liner tests from five different sites in the course of the year (January to December, 2006) has been incorporated into the 2006 LinerReport. In case of repeat tests, the most recently obtained result is used, provided the repeat tests were also performed at IKT. This report is based on a total of 1084 site samples taken at construction sites throughout Germany and thoroughly tested at the IKT laboratory.

The 2006 IKT-LinerReport submitted herewith provides an overall view of tube liner qualities, classified by installation companies and liner systems. It follows the 2003/2004 and 2004/2005 LinerReports, and is therefore the Institute's third report of this type (see IKT-eNewsletters for September 2004 and January 2006 on www.ikt.de).

Significance and Limits of Information

The laboratory results, obtained from site samples, cannot be used as the sole criteria for assessment of specific lining projects, since site specimens are only, at best, random samples. They are normally taken in the manhole or, in exceptional cases, directly from the pipe.

The overall condition of a renewed pipe can be evaluated only if further acceptance inspection procedures, such as camera inspection or internal manual inspection, are also included. Only these other methods detect wrinkles, incorrectly re-opened service connections and physical defects in the pipeliner.

The IKT-LinerReport can therefore, not constitute the only standard for comparative assessment of installation companies and their liner systems. It provides results based on only one – but extremely important – aspect of quality assurance: laboratory testing.

Specified/Actual Analysis

At least four different parameters are generally used for the assessment of building site samples:

- Modulus of elasticity (short-term flexural modulus)
- Flexural strength (short-term σ_{fb})
- Wall thickness
- Impermeability to water (water tightness)

In the case of the first three (mechanical) parameters, the specified results are compared against those actually achieved (Specified/Actual analysis). The fourth criterion, water-tightness or porosity, is determined in accordance with the APS test and inspection code. The result is either „Porous" or „Non-Porous".

Table 1 – Installation Companies and Liner Systems

Installation Company	Liner System	Liner Type	No. of Samples tested	IKT test commissioned by	
				Installation company %	Municipal client %
ARKIL INPIPE GmbH	Berolina Liner	GRP	213	40	60
Boger Kanalsanierung GmbH	iMPREG-Liner	GRP	40	0	100
Brandenburger Kanalsanierungs-GmbH	Brandenburger Tubeliner	GRP	57	14	86
Diringer & Scheidel Rohrsanierung GmbH & Co. KG	Uniliner (NordiTube)	NF	36	6	94
	CityLiner (RS Technik AG)	NF	69	0	100
	Saertex-Liner	GRP	33	100	0
FLEER-TECH GmbH	CityLiner (RS Technik AG)	NF	42	17	83
Frisch & Faust Tiefbau GmbH	Saertex-Liner	GRP	180	0	100
Hans Brochier GmbH & Co. KG	Saertex-Liner	GRP	35	66	34
Insituform Rohrsanierungstechniken GmbH	Insituform Tubeliner	NF	215	3	97
KS Kanalsanierung Friedrich e.K.	Brandenburger Tubeliner	GRP	83	37	63
Linertec GmbH	Euroliner	GRP	43	28	72
Swietelsky-Faber GmbH Kanalsanierung	Berolina-Liner	GRP	38	0	100
Total			**1,084**	**18**	**82**

GRP: Glass-fiber-reinforced support material
NF: Needle-felt support material

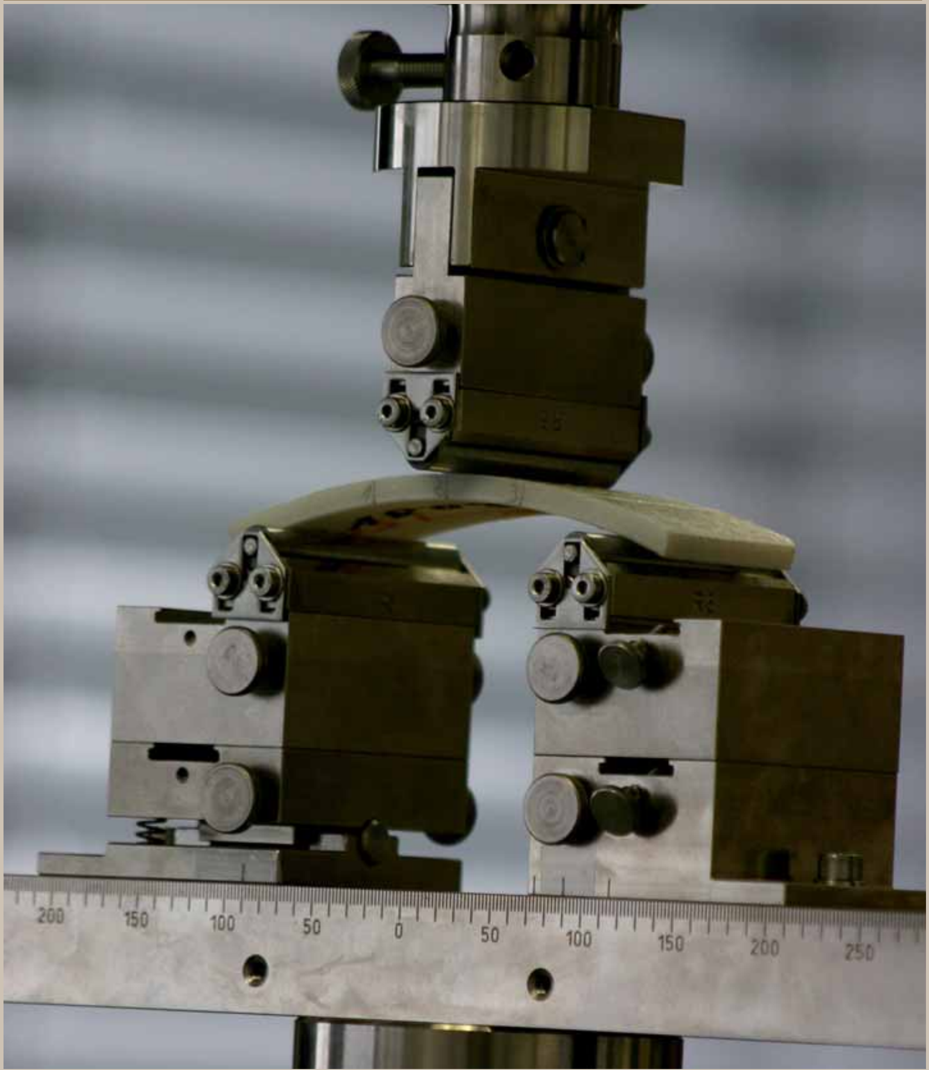


Figure 1: Liner sample undergoing three-point bending test

Table 2 - Test Criteria: Modulus of Elasticity (Short-term flexural modulus)

Installation Contractor	2006		2004/2005	Trend
	No. of Samples	Target* achieved in % of tests	Target* achieved in % of tests	
Brandenburger Kanalsanierungs-GmbH	57	100.0	97.6	↑
Hans Brochier GmbH & Co. KG	35	100.0	99.1	↑
Linertec GmbH	43	100.0	97.1	↑
ARKIL INPIPE GmbH	210	99.5	97.3	↑
KS Kanalsanierung Friedrich e.K.	80	98.8	97.1	↑
KMG Pipe Technologies GmbH	22	–	96.2	–
Diringer & Scheidel – Saertex-Liner	33	93.9	–	–
Average		**89.9**		
Swietelsky-Faber GmbH Kanalsanierung	38	89.5	–	–
Frisch & Faust Tiefbau GmbH	180	88.3	–	–
Boger Kanalsanierung GmbH	40	87.5	–	–
Insituform Rohrsanierungstechniken GmbH	215	84.2	87.8	↓
Diringer & Scheidel – CityLiner	65	75.4	–	–
Diringer & Scheidel – Uniliner	36	75.0	–	–
FLEER-TECH GmbH	41	63.4	77.8**	↓

* Target values as per stress analysis or client's data on the sample traveller card
** Applies to RS RoboLiner
– not evaluated (too few liner samples)

Figure 2: Measurement of liner wall thickness

Costumers Must Test

The clients for tests in 2006 included both municipalities and installers. IKT has, however, always emphatically recommended that municipal clients (or their consultant engineers), rather than the installers, should select and commission the testing institute directly. The testing function must not be left to those who's products are being tested. In this way, potential attempts at influence, by such companies, can be eliminated from the beginning. The majority of tests performed at IKT, a total of 82 %, were conducted on behalf of the municipal client (see Table 1).

Modulus of Elasticity

Pipe liners are required to withstand locally differing loads (groundwater, traffic loads, soil pressure etc.). They therefore need to be designed specifically for these loads in each case, and to possess adequate load-bearing capability. A central mechanical characteristic parameter in this context is modulus of elasticity. The test method applied in the case of site samples is the three-point bending test, which IKT performs in the form of a short-time test with reference to DIN EN ISO 178 and DIN EN 13566, Part 4 (see Table 2).

Flexural Strength

Flexural strength indicates the point at which the liner fails as a result of excessively high stress. If this point is too low, the liner does not possess adequate load-bearing capability and may fail before the permissible load is reached. Test method: The load in the three-point bending test

Table 3 - Test Criteria: Flexural Strength (short-time σ_{fb})

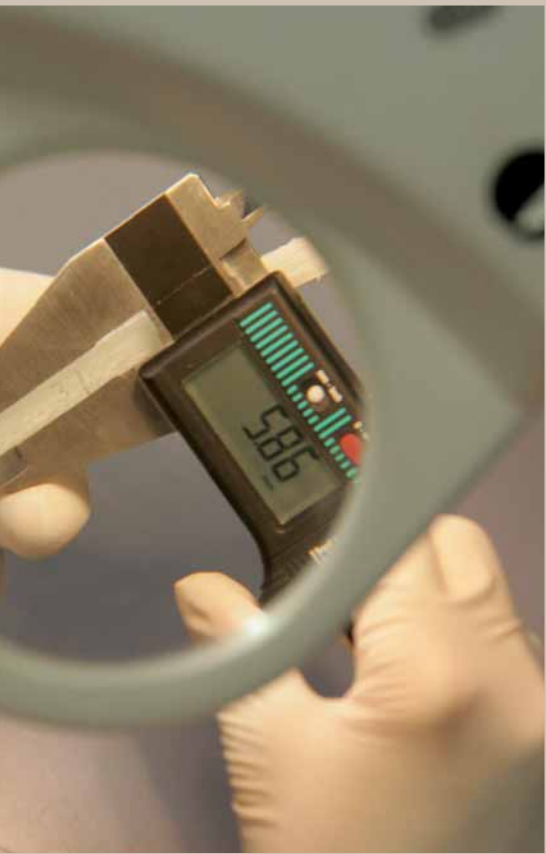
Installation Contractor	2006		2004/2005	Trend
	No. of Samples	Target* achieved in % of tests	Target* achieved in % of tests	
Boger Kanalsanierung GmbH	40	100.0	–	–
Brandenburger Kanalsanierungs-GmbH	57	100.0	100.0	←→
KS Kanalsanierung Friedrich e.K.	80	100.0	98.5	↑
Linertec GmbH	41	100.0	91.2	↑
Diringer & Scheidel – CityLiner	65	98.5	–	–
ARKIL INPIPE GmbH	210	92.4	97.3	↓
Hans Brochier GmbH & Co. KG	35	91.4	96.4	↓
Diringer & Scheidel – Saertex-Liner	33	87.9	–	–
Swietelsky-Faber GmbH Kanalsanierung	36	86.1	–	–
FLEER-TECH GmbH	41	85.4	100.0**	↓
Average		**83.5**		
Frisch & Faust Tiefbau GmbH	180	78.9	–	–
Diringer & Scheidel – Uniliner	36	75.0	–	–
Insituform Rohrsanierungstechniken GmbH	215	56.3	74.0	↓
KMG Pipe Technologies GmbH	22	–	50.0	–

* Target values as per stress analysis or client's data on the sample traveller card
** Applies to RS RoboLiner
– not evaluated (too few liner samples)

Table 4 - Test Criteria: Wall Thickness (Mean Combined

Installation Contractor	2006
	No. of Samples
Diringer & Scheidel – Saertex-Liner	33
Frisch & Faust Tiefbau GmbH	180
Hans Brochier GmbH & Co. KG	34
KMG Pipe Technologies GmbH	22
Linertec GmbH	43
FLEER-TECH GmbH	40
Brandenburger Kanalsanierungs-GmbH	57
Diringer & Scheidel – Uniliner	26
Diringer & Scheidel – CityLiner	48
Average	
Insituform Rohrsanierungstechniken GmbH	193
Boger Kanalsanierung GmbH	38
ARKIL INPIPE GmbH	210
Swietelsky-Faber GmbH Kanalsanierung	38
KS Kanalsanierung Friedrich e.K.	80

* Target values as per stress analysis or client's data on the sa
** Applies to RS RoboLiner
– not evaluated (too few liner samples)



is raised at a constant rate of deformation up to the first fall in loading. This indicates the inception of liner failure (short-time test, see Table 3).

Wall Thickness

The third criteria relevant for assessment of the load-bearing capability of liners is wall thickness (Mean Combined Thickness e_m as per DIN EN 13566, Part 4). A specified figure (for the stress-analysis calculation, for example), is made for this and must be achieved during production of the liner on site. Test method: The statically load-bearing wall thickness is measured at six points using a precision slide gauge. Inner and outer films and non-structured layers consisting purely of resin (surplus resin layers) are not taken into account in this measurement (see Table 4).

Water-Tightness as per APS

Test method: Any outer film is firstly removed from the sample and a specified pattern is cut into the inner film. Water containing a red dye-stuff is then applied to the inner side and an „underpressure“ (partial vacuum) of 0.5 bar is applied to the exterior side. The liner is „Porous“ (not water-tight) if droplets, foam or moisture form on the outer side (see Table 5).

Liner Types and Liner Systems

Analysis of the liner types and systems evaluated and tested indicates the following (see Table 6):

- GRP liners systematically achieve better test results than needle-felt liners for the criteria of water-tightness and modulus of elasticity. This correlation is slightly less pronounced in the case of bending tension. No systematic correlation between liner-type and test results is discernible in the case of the wall-thickness criteria.
- Quality differences, of considerable significance in some cases, become apparent within the two materials groups, i.e., GRP and needle-felt; the results obtained with needle felt for the criteria of water-tightness and flexural strength, for example, fluctuate greatly. They are tightly grouped only for wall thickness. The results for GRP products scatter much less, the sole exception being wall thickness, where a significant bandwidth exists.

Figure 3: Water (stained red) permeates through: Liner is not water-tight

Thickness $_{em}$ as per DIN EN 13566, Part 4)

		2004/2005	Trend
	Target* achieved in % of tests	Target* achieved in % of tests	
	100.0	–	–
	100.0	–	–
	100.0	96.9	↑
	–	100.0	–
	97.7	97.1	↑
	95.0	90.5**	↑
	89.5	67.9	↑
	88.5	–	–
	85.4	–	–
	82.7		
	80.0	92.0	↓
	73.7	–	–
	68.6	90.0	↓
	63.2	–	–
	62.5	47.3	↑

mple traveller card

Table 5 - Test Criteria: Water-Tightness (in conformity with APS test and inspection code)

Installation Contractor	2006		2004/2005	Trend
	No. of Samples	Non-porous in % of tests	Non-porous in % of tests	
Boger Kanalsanierung GmbH	38	100.0	–	–
Brandenburger Kanalsanierungs-GmbH	57	100.0	100.0	↔
Diringer & Scheidel – Saertex-Liner	33	100.0	–	–
Linertec GmbH	43	100.0	100.0	↔
Swietelsky-Faber GmbH Kanalsanierung	33	100.0	–	–
KS Kanalsanierung Friedrich e.K.	83	98.8	100.0	↓
ARKIL INPIPE GmbH	184	97.8	98.6	↓
Hans Brochier GmbH & Co. KG	35	97.1	98.2	↓
Frisch & Faust Tiefbau GmbH	180	93.3	–	–
Diringer & Scheidel – CityLiner	53	92.5	–	–
Average		**88.8**		
KMG Pipe Technologies GmbH	22	–	75.0	–
Insituform Rohrsanierungstechniken GmbH	192	68.8	62.6	↑
FLEER-TECH GmbH	42	61.9	81.8**	↓
Diringer & Scheidel – Uniliner	27	48.1	–	–

** Applies to RS RoboLiner
– not evaluated (too few liner samples)

Figure 5: Test engineer explaining test procedure: Dipl.-Ing. Jens Fuchs in the IKT laboratory

Installation Contractors

The quality of execution by the installers is however, also a critical factor in the achievement of success. This is apparent, in particular, in the case of liner systems which are used by more than one company, i.e., Berolina Liners, Brandenburger Tube Liners, City-Liners and Saertex-Liners. The scatter bandwidth of rates of success (percentage of tests passed) per liner system is significant for a number of test criteria (see Table 7).

Conclusion

Pipe lining continues to provide project customers with a suitable and reliable renewal method. The majority of installation contractors performed work which can be classified as good to extremely good in the twelve months of 2006. This is documented by high rates of testing success, ranging up to 100 %. Comparison with the 2004/2005 LinerReport indicates that many companies have actually succeeded in improving their performance, or at least keeping it at a constant high standard.

This constant high standard is extremely positive with a view to achievement of technically sound, cost-efficient and environmentally safe renewal of drain and sewer pipelines. It does, however, become exceedingly clear that a number of installation contractors still have adequate margin for improvement of their liner quality and work. This applies particularly to those companies using needle-felt liners. This group of technologies needs to improve their quality to catch up with the GRP liners in the fields of water-tightness, modulus of elasticity and flexural strength.

In the case of the „GRP liner companies“ however, the picture is also not totally perfect; here, too, the scatter bandwidths demonstrate that on-site quality is not always at a consistently high level.

Intensified efforts in the fields of product improvement, development and quality assurance are now at the very top of the agenda, if the tube lining „family“ is not to fall behind competing methods as the pipe rehabilitation market continues to grow. ▮

Table 6 - Results Classified by Liner Types

		Water-Tightness		Modulus of Elasticity		Flexural Strength		Wall Thickness	
Liner Type	Liner System	No. of Samples	Non-Porous in % of tests	No. of Samples	Target achieved in % of tests	No. of Samples	Target achieved in % of tests	No. of Samples	Target achieved in % of tests
GRP	Euroliner	43	100.0	43	100.0	41	100.0	43	97.7
	Brandenburger Tubeliner	140	99.3	137	99.3	137	100.0	137	73.7
	Berolina Liner	217	98.2	248	98.0	246	91.5	248	67.7
	Saertex-Liner	248	94.8	248	90.7	248	81.9	247	100.0
	iMPREG-Liner	38	100.0	40	87.5	40	100.0	38	73.7
NF	CityLiner (RS Technik)	95	78.9	106	70.8	106	93.4	88	89.8
	Uniliner (NordiTube)	27	48.1	36	75.0	36	75.0	26	88.5
	Insituform Tubeliner	192	68.8	215	84.2	215	56.3	193	80.8
Averages • of all samples • GRP samples • NF samples			88.8 97.4 70.1		89.9 95.2 79.3		83.5 90.7 69.2		82.7 82.2 84.0

(green) above overall average
(red) below overall average
GRP: Glass-fiber-reinforced plastic support material
NF: Needle-felt support material

Table 7 - Bandwidth of Test Results (where liner system used by more than one installation contractor)

Liner System	**Water-Tightness** Non-Porous in % of tests	**Modulus of Elasticity** Target achieved in % of tests	**Flexural Strength** Target achieved in % of tests	**Wall Thickness** Target achieved in % of tests
Berolina Liner	97.8 – 100.0	89.5 – 99.5	86.1 – 92.4	63.2 – 68.6
Brandenburger Tubeliner	98.8 – 100.0	98.8 – 100.0	100.0 – 100.0	62.5 – 89.5
CityLiner	61.9 – 92.5	63.4 – 75.4	85.4 – 98.5	85.4 – 95.0
Saertex-Liner	93.3 – 100.0	88.3 – 100.0	78.9 – 91.4	100.0 – 100.0

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