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The range is widening

by Roland W. Waniek and Dieter Homann

The IKT presents for the second time a statistical evaluation of its tube liner database. The objective is enhanced transparency in rehabilitation quality matters. In the 18 months that have passed since the first LinerReport was published, some trends have established themselves and new developments have appeared.

The IKT LinerReport 2003/2004 statistically documented for the first time (see bi-UmweltBau No. 5/2004) how rehabilitation performances vary in practice. The IKT tube liner database has now been evaluated for the period July 2004 to December 2005. It shows that the rehabilitation quality range continues to widen.

Longer service life in a falling market?

Sewer network operators are increasingly resorting to the leading rehabilitation technology, tube lining, primarily due to the lower cost. It appears that this trend will intensify in the coming years because the need for rehabilitation is increasing – however, local investment budgets are hardly growing.

Rehabilitation companies promise longer life spans – 50 or more years. Critical customers ask how this relates to the ongoing price decline. Many of them are concerned about a reduction in quality. The topic of quality assurance of tube liners is booming: customers want to know what they are going to get for their money.

Quality assurance is „in"

Tube liner quality is a top subject at many conferences (e.g., Göttingen, Oldenburg, Tube Liner Day). Municipal contractors have reacted by including explicit quality requirements in their bids. Hamburg has been doing so for some years, and seven large southern Germany cities are following this procedure with technical specifications.

Advanced training is also on the upswing: The VSB course „Certified Sewer Rehabilitation Advisor" is becoming increasingly popular and the FH Kaiserslautern now offers a part time master study for future rehabilitation experts.

The „Working Group of Tube Liner Testing Institutes" (APS) has been newly established with the objective of defining uniform test guidelines. This working group has precisely defined the leak test procedure and specified stricter evaluation standards (APS Guideline, see bi-UmweltBau No. 5/2004). Further test guidelines are being prepared.

Bringing building site samples into the laboratory

A very important quality assurance instrument is the analysis of tube liner samples taken from the building site. The contractor has liner sections removed from the shaft or from the cured pipe shortly after curing and sends them to the laboratory. The IKT then tests four main criteria: elastic modulus, bending tensile strength, wall thickness and water tightness.

The contractor receives a detailed test report containing the results and further documentation in illustrations and tables. This is a valuable aid during building site acceptance and refers to weaknesses, which will possibly require reworking.

Significance limits

Laboratory results of building site samples cannot be the exclusive criteria for evaluating a specific rehabilitation measure. Building site factors (e.g., how and where the sample was taken), cannot be considered with regard to the sample quality. These factors are not usually known by the examiners.

Building site samples are always random samples. They are usually removed from a shaft or, in exceptional cases, directly out of the cured pipe. Therefore, it is not possible to evaluate the overall condition of the rehabilitated cured pipe in many cases. Additional acceptance examinations are necessary, such as camera examination or inspection. Only this will enable identification of folds, inappropriately integrated house connections or partial flaws in the cured pipe.

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With this in mind, results of the IKT LinerReports are not suitable as final or exclusive benchmarks in the evaluation or comparison of the rehabilitation companies and their liner systems. The liner report only provides an overview of the market situation by means of only one –although a very important – aspect of quality assurance.

Data pool

The IKT continuously enters its examination results concerning building site samples into a database. This very substantial and important database on the quality of tube liner measures is constantly growing, as are the samples, which are kept for five years and can be accessed at any time. This is the basis of the IKT-LinerReport.

To be considered in the IKT LinerReport, a liner system rehabilitation company must have submitted at least 25 liner samples from building sites in five different municipalities and/or contractors. Liner systems are not included if they do not fulfil these minimum criteria.

The evaluation considers all test reports concluded between July 2004 and December 2005. Only the final result is considered in cases of multiple or repeated examinations as long as these repeated examinations were performed by the IKT.

The current IKT LinerReport is based on 747 examined building site samples reflecting approximately 62 rehabilitated sewer miles.

Target-actual-analysis

Tube liners are drawn into cured pipes and only there do they cure to sustainable pipe-in-pipe systems. Liner specifications are calculated beforehand (e.g., target values for wall thickness and mechanical characteristic values). The bearing strength and indentation security of a liner can be in jeopardy, if the actual values are less than those specified.

The target-actual analysis is aggregated in the IKT LinerReport for the referenced rehabilitation companies. The following characteristic values are determined for each building site sample:

- Elasticity modulus (Short-term E-modulus),
- Bending tensile strength ((Short-term-σ_{bz}) and
- Wall strength.

Contractors inform the IKT of the target values. They normally result from the approvals or from building site-specific liner statics. The result tables show for each rehabilitation company and/or liner system:

- the number of examinations that meet the target values, and
- the average and maximum shortfall of the target values in percentage in all other cases.

Liner samples are further tested for watertightness, a main criteria in the evaluation of rehabilitation measures. These results can only be either „watertight" or „water-permeable".

Rehabilitation and liner systems

The referenced rehabilitation companies use, in part, very different liner systems. Some companies work with more than one system. Only liner system values are considered in the statistics of the IKT LinerReport, which fulfil the minimum requirements (25 samples from 5 different building sites).

Both contractors (network operators and their engineering departments) and rehabilitation companies request the examinations. Contractors commission 60% of the examinations. See table 1.

E-Modulus

Tube liners must tolerate different local loads (groundwater, traffic, earth pressure). They must be designed for these cases and have an adequate load-carrying capacity. The elastic modulus is the main appropriate mechanical characteristic value. The three point bending test is used as testing method for building site samples; the IKT accomplishes this as a short-term test following DIN EN ISO 178 and DIN EN 13566-4. See table 2.

Fig. 1: Experimental setup of the three point bending test

Tab. 1: Rehabilitation and liner systems

Sanierungsfirmen	Liner system	IKT examination commissioned by	
		Rehabilitation company %	Network operator/ engineering department %
ARKIL INPIPE GmbH	BKP Berolina	25	75
Brandenburger Kanalsanierungs-GmbH	Brandenburger	31	69
FLEER-TECH GmbH	RS-RoboLiner	79	21
Hans Brochier GmbH & Co. KG	Saertex	72	28
Insituform Rohrsanierungstechniken GmbH	Insituform	16	84
KMG Rohrtechnik GmbH	KM Inliner	33	67
KS Kanalsanierung Friedrich e.K.	Brandenburger	87	13
Linertec GmbH	Euroliner	9	91

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Tab. 2: Test criterion elasticity modulus (Short term E-modulus)

Rehabilitation companies	Quantity samples	Target value* achieved in % of the examinations	Shortfall target value*	
			average %	maximum %
Hans Brochier GmbH & Co. KG	111	99.1	6.7	6.7
Brandenburger Kanalsanierungs-GmbH	84	97.6	10.5	14.1
ARKIL INPIPE GmbH	73	97.3	9.1	17.4
KS Kanalsanierung Friedrich e.K.	68	97.1	10.1	17.4
Linertec GmbH	34	97.1	6.1	6.1
KMG Rohrtechnik GmbH	52	96.2	21.1	32.6
Insituform Rohrsanierungstechniken GmbH	246	87.8	22.2	68.5
FLEER-TECH GmbH	63	77.8	15.0	35.2

* Target value according to statics or contractor specifications in the sample supply note

Tab. 3: Test criterion bending tensile strength (Short-term-σ_{bz})

Rehabilitation companies	Quantity samples	Target value* achieved in % of the examinations	Shortfall target value*	
			average %	maximum %
Brandenburger Kanalsanierungs-GmbH	84	100.0	0.0	0.0
FLEER-TECH GmbH	63	100.0	0.0	0.0
KS Kanalsanierung Friedrich e.K.	68	98.5	36.2	36.2
ARKIL INPIPE GmbH	73	97.3	37.5	62.6
Hans Brochier GmbH & Co. KG	111	96.4	24.4	34.5
Linertec GmbH	34	91.2	19.3	35.0
Insituform Rohrsanierungstechniken GmbH	246	74.0	9.7	36.0
KMG Rohrtechnik GmbH	52	50.0	10.9	31.9

* Target value according to statics or contractor specifications in the sample supply note

Bending tensile strength

The bending tensile strength marks the point at which a liner fails because of too high tension. The liner cannot carry sufficient loads if it is too low and can break before achieving a permissible deformation. Examination method: The load is increased up to the first load drop in the three point bending test, which marks the beginning of the liner breakage (short-term test). See table 3.

Wall strength

Wall thickness is the third criterion in the evaluation of liner load-carrying capacity. As in the previous cases, an assumption is made (e.g., the static calculation), which must be achieved when fabricating the liner on the building site. Examination method: The statically load-carrying wall thickness is measured at six locations with a precision sliding caliper. Internal and external films as well as surplus resin are not considered. See table 4.

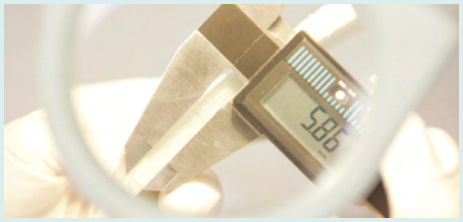

Fig. 2: Measurement of the liner wall thickness

Watertightness

Examination method: The external film of the sample is first removed, if present, and the internal film cut according to a defined pattern. Red colored water is then applied to the interior wall and 0.5 bar vacuum is applied to the exterior wall. The liner is water permeable if drops, foam or moisture develop on the outside.

All liner samples were examined according to this so-called APS Guideline (see bi-UmweltBau No. 5/2004, P. 60-61). The only exception: Insituform liners were submitted to a deviating examination (23% of the cases) at the request of some contractors. The water loss on the examination surface was measured and compared to a permissible water addition quantity (here: 0.15 l/sqm) according to DIN EN 1610. A liner is still evaluated as watertight, if it lets water leak up to this maximum amount. See table 5.

Fig. 3: Examination of the watertightness according to the APS-Guideline

Tab. 4: Test criterion wall thickness

Rehabilitation companies	Quantity samples	Target value* achieved in % of the examinations	Shortfall target value*	
			average %	maximum %
KMG Rohrtechnik GmbH	52	100.0	0.0	0.0
Linertec GmbH	34	97.1	8.8	8.8
Hans Brochier GmbH & Co. KG	97	96.9	2.6	2.8
Insituform Rohrsanierungstechniken GmbH	200	92.0	6.0	15.8
FLEER-TECH GmbH	63	90.5	12.1	42.2
ARKIL INPIPE GmbH	70	90.0	8.8	23.2
Brandenburger Kanalsanierungs-GmbH	84	67.9	7.5	24.0
KS Kanalsanierung Friedrich e.K.	55	47.3	8.8	23.1

* Target value according to statics or contractor specifications in the sample supply note

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Tab. 5: Test criterion watertightness*

Rehabilitation companies	Quantity samples	water-tight %
Brandenburger Kanalsanierungs-GmbH	84	100.0
KS Kanalsanierung Friedrich e.K.	54	100.0
Linertec GmbH	34	100.0
ARKIL INPIPE GmbH	71	98.6
Hans Brochier GmbH & Co. KG	109	98.2
FLEER-TECH GmbH	55	81.8
KMG Rohrtechnik GmbH	52	75.0
Insituform Rohrsanierungs-techniken GmbH a) according to APS-Guideline b) following DIN EN 1610 (Explanation see text)	 198 59	 62.6 83.1

* according to APS-Guideline, if not otherwise specified

Conclusion

The IKT LinerReport 2004/2005 shows a differentiated overall view of the rehabilitation quality during an 18-month period. More than 700 liner samples taken from building sites were tested concerning their static characteristic values and watertightness.

Tab 6 gives an extremely condensed overview of the tube liner qualities with the average values of all examination results. It should reassure the contractors that the large majority of the tube lining measures exhibit good values – some can even be considered very good.

The current discussion on tube liner qualities is, however, justified. The statistics reveal considerable examination result fluctuations. Some of the suppliers succeed in fulfilling the requirements regularly, while others demonstrate clear fluctuations in their performance qualities.

What must be done?

The results highlight weak points and, therefore, provide rehabilitation companies and liner manufacturers with valuable information that identifies where they must improve their products and performance efficiency. This should be seen as an opportunity to further develop their products. After all, it is in their best interest that customers continue to have confidence in tube liner technology.

The IKT LinerReport shows contractors very clearly that precise monitoring of building site quality is of great importance. They must take the lead concerning quality assurance and investigate whether the promised characteristic values are actually complied with. Too many contractors still leave the quality inspection to those who should really be monitored (i.e., the rehabilitation companies).

Quality assurance must start long before acceptance. Knowledge of available technologies, further and advanced training, sound planning and bidding are important elements.

Contractors should evaluate various options offered by procurement law and consider quality criteria (not only price) in their decisions. One thing is obvious -- customers are at an advantage with regard to the long-standing overcapacities in the building industry. All they must do is clearly formulate their quality requirements and ensure that these are complied with. Reha-bilitation companies who are willing and able to fulfil these requirements can be found.

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Tab 6: Total overview examination results

Test criterion	Sum of all samples	Target value achieved and/ or watertight in % of the examinations
Elasticity modulus (Short term E-modulus)	731	92,6
Bending tensile strength (Short-term-σ_{bz})	731	86,3
Wall strength	655	86,4
Watertightness	716	84,6