



Watertight or not? Water tightness testing in the IKT laboratory

15 years of the IKT LinerReport

# Has the trend for improving sewer lining quality ended?

For more than ten years, the performance of CIPP liners continuously improved. But, in recent years the annual test results have sometimes been poorer. Is this a sign of a reversal in that trend?

by Roland W. Waniek, Dieter Homann and Barbara Grunewald

Fifteen years ago, IKT - Institute for Underground Infrastructure published its first LinerReport and has repeated this exercise every year since. Altogether, these reports include the test results from some 23,000 samples taken from installed Cured In Place Pipe (CIPP) liners in sewers. This represents sampling from an estimated 2 to 2.5 million meters of lining installed in rehabilitated sewers. The samples used for the LinerReport are taken at

sewer rehabilitation sites shortly after the installation of a CIPP lining and are then tested at IKT's two materials testing laboratories, in Germany and in The Netherlands (since 2013). Four test criteria are applied: modulus of elasticity, flexural strength, wall thickness and water tightness (see test criteria box). These tests were agreed in the mid-2000s by experts from municipalities, engineering consultancies, manufacturers, installers and testing labo-

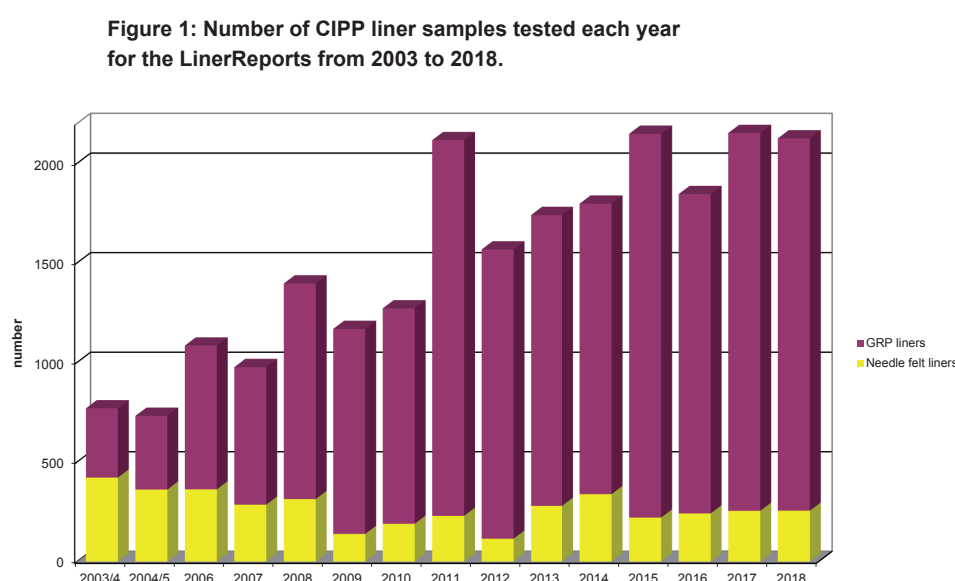
## Database for the 2018 IKT LinerReport

- Number of pipe liner samples included: 2,125
- Of these: 1,870 are GRP liners and 255 needle felt liners
- Minimum quantity required for entry in the LinerReport: 25 liner samples per rehabilitation company of one liner type, from at least five different installation sites
- Sample providers: 72% sewer network owners and 28% lining companies
- Countries of origin: Belgium, Czech Republic, Germany, Switzerland, The Netherlands and United Kingdom.

ratories, because they are highly informative about the installed quality of a CIPP liner. They are also quick and inexpensive to carry out. Subsequently, these test standards have been incorporated into the DWA regulations (DWA A 143-3 and M 144-3) and into the approval criteria of the German Institute for Building Technology (DIBt), which is the supervisory approval body for CIPP liners. IKT LinerReports are annual summaries of the performance of liner installations determined by comparing the observed test results against the expected performance values for each individual sample. Each report shows how individual lining installation companies performed against the four test criteria in a calendar year and gives an indication of the performance of the sewer lining industry as a whole. Consequently, IKT LinerReports provide market transparency for the specialist public, particularly for the operators of wastewater networks who commission sewer rehabilitation to prolong the life of their assets.

## The debate about liner quality assurance

Triggered not least by the early IKT LinerReports, there was fierce controversy until the mid-2000s in Germany about whether and how to take the CIPP liner tests. Different economic interests and quality requirements collided: on the one hand between the suppliers and customers and, on the other, between the suppliers competing for market share. Above all, the wastewater network operators were demanding a high level of quality for installed CIPP liners and corresponding quality testing, since their requirement for the sewer lining industry is for it to supply reliable, long-lasting sewer renovations with a service life of up to 50 years. For this reason, the network operators were successful in their de-



mands: for testing of installed CIPP liners for stability and water tightness; for testing on actual installed liner samples; compliance with established guidelines and testing by independent third parties.

## Looking back at 15 years of liner performance

Of the approximately 23,000 samples taken from installed CIPP liners included in the IKT LinerReports, around 82% have been from glass fibre reinforced plastic (GRP) liners and 18% from needle felt (NF) liners. At the beginning, both types of carrier material were almost equally represented, but from 2006 onwards the GRP liners began to be favoured and now dominate (Figure 1). This primarily reflects developments in the German market, but other markets are also gradually following this

trend with The Netherlands and Switzerland recording strong GRP liner growth.

## Positive overall trends

The overall trends observed in the test results over the last 15 years have been positive. Until the mid-2000s, 15 to 17 percent of all pipe liner samples did not pass the tests. Since then, the failure rate has reduced to 1 to 6 percent, which is a pleasing overall picture. However, this is slightly clouded by the fact that after very good success rates, approaching 100 percent for some test criteria, the proportion of failed tests has noticeably increased in the second half of the 2010s, with the exception of water tightness (Figure 2).

Overview of testing criteria	
<b>Modulus of elasticity</b> (short-term flexural modulus) <ul style="list-style-type: none"> <li>CIPP liners must be capable of bearing loads such as groundwater, road traffic and soil pressure</li> <li>The modulus of elasticity is an indicator of load-bearing capability</li> <li>Stability may be endangered if the modulus of elasticity is too low</li> <li>Test method: three-point bending test in accordance with DIN EN ISO 178 and DIN EN ISO 11296-4</li> </ul> <p>&gt; Results: see Tab. 1</p>	<b>Wall thickness</b> (average composite thickness) <ul style="list-style-type: none"> <li>Excessively low wall thickness can endanger stability</li> <li>Minimum values are specified in structural analysis calculation</li> <li>Wall thickness and modulus of elasticity jointly determine the stiffness of the liner</li> <li>Test method: with precision a caliper, average composite thickness is measured in accordance with DIN EN ISO 11296-4</li> </ul> <p>&gt; Results: see Tab. 1</p>
<b>Flexural strength</b> (Flexural stress at first break = short-term $\sigma_{fb}$ ) <ul style="list-style-type: none"> <li>This denotes the point at which the liner fails due to excessive high stress</li> <li>The liner may rupture before the permissible deformation is reached if flexural strength is too low</li> <li>Test method: Increase of load up to failure in the three-point bending in accordance with DIN EN ISO 178 and DIN EN ISO 11296-4</li> </ul> <p>&gt; Results: see Tab. 1</p>	<b>Water tightness</b> <ul style="list-style-type: none"> <li>The inner liner is cut if it is not an integral component of the liner</li> <li>Any outer film is removed if it is not an integral component of the liner</li> <li>Water containing a red dye is applied to the inner surface</li> <li>A 0.5 bar partial pressure is applied to the external surface</li> <li>The liner is "not tight" if water penetrated through</li> <li>Test duration: 30 min</li> </ul> <p>&gt; Results: see Tab. 1</p>
A detailed description of these tests can be found on the IKT website: <a href="http://www.ikt-online.org/cipp-liner/cipp-liners-site-samples/">www.ikt-online.org/cipp-liner/cipp-liners-site-samples/</a>	





Wall thickness measurement: requires particularly high precision

### Has the trend been broken after 15 years?

The development of CIPP liner quality in the last 15 years has been characterised by two phases: first a strong improvement from 2003/04 to 2013/15 and then a second phase of slightly decreasing success rates. This is also illustrated by considering how many lining companies pass each test with all their samples. In 2015, almost 70% of the compa-

nies succeeded in passing the Modulus of Elasticity test criterion for all the samples submitted. From then on, the trend reversed and the proportion of companies that passed with all samples dropped to 35% by 2018 (Figure 3). Similar trends can also be observed for the other three test criteria. In 2011, 75% of the lining companies passed the bending strength test, seven years later it is only 45%. For wall thickness, 2013

was the best year with 53% of companies passing these tests with all their samples, compared to only 35% in 2018. Only for water tightness is the decline somewhat smaller, from 70% of companies in 2010 to 55% in 2018 (Figure 3).

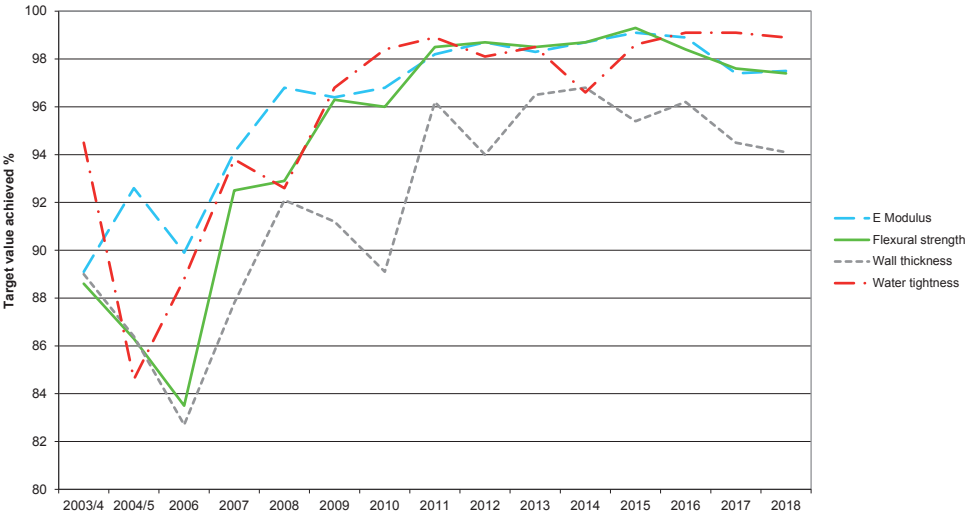
### Wall thickness is a particular problem

The wall thickness test criterion shows the weakest performance among the four tests in all 15 years of the IKT LinerReport, consistently recording the lowest pass rates. Although the results of the wall thickness tests today are better than 15 years ago, with a success rate of 94% in 2018, it remains the criterion with the worst results. It should be borne in mind that this failure rate of 6% means that approximately every 15th liner does not achieve the wall thickness expected by the customer (Figure 2).

### Comparison of GRP and needle felt liners

Both GRP and NF liners show improved performance over the last 15 years. For NF liners, this improvement is more pronounced, albeit from a lower initial level than for GRP liners. The GRP pass rates are in a narrow range of 95 to 99 percent over almost all years. The only exception is the wall thickness, which in the case of GRP liners is significantly weaker than the other three test criteria (Figures 4 and 5). NF liners, on the other hand, show a significantly

**Figure 2: Annual test results from 2003 to 2018 showing the percentage of samples achieving their target value.**



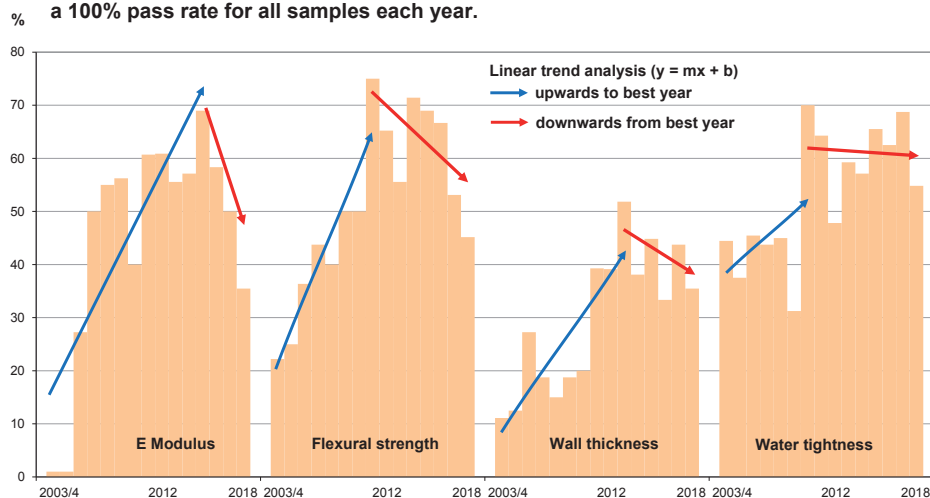
higher variance in their test results over time. Only in the last three years have the results of the four criteria settled at a high level between 95 and 100 percent. It is noteworthy that no NF liner has failed the water tightness test for the past two years, as for many years NF liners performed poorly for this test (Figure 5).

## 2018 results

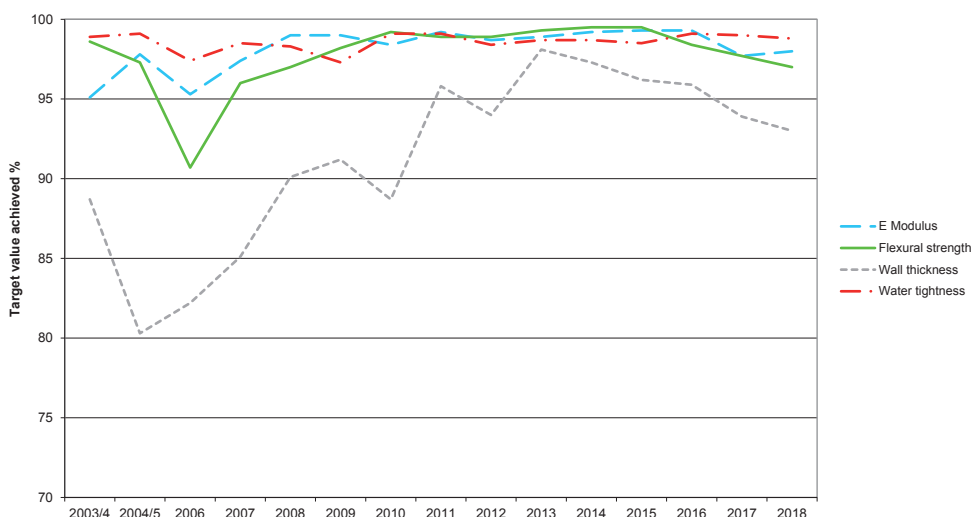
The latest IKT LinerReport includes more than 2,100 liner samples, taken at installation sites in 2018 for quality control purposes and examined by the IKT testing laboratories. As in previous years, the modulus of elasticity, bending strength, wall thickness and water tightness were determined for each site sample. In each case performance has been determined by comparing the test results with the expected target values derived for each sample from the relevant product approval (Germany: DIBt Approval; The Netherlands: KOMO certificate; Switzerland: QUIK guideline) or client information, e.g. static design calculations.

Tables 1 and 2 show the 2018 test results for each lining company and for each liner system, respectively. The average proportion of passed tests results for the four test criteria remained at a high level in 2018 (mean values: 98.9%; 97.5%; 97.4%; 94.1%), similar to the previous year's level, with a very small improvement in the modulus of elasticity and very small declines in the other three criteria (see Table 3). 2018 was a good year overall for liner quality.

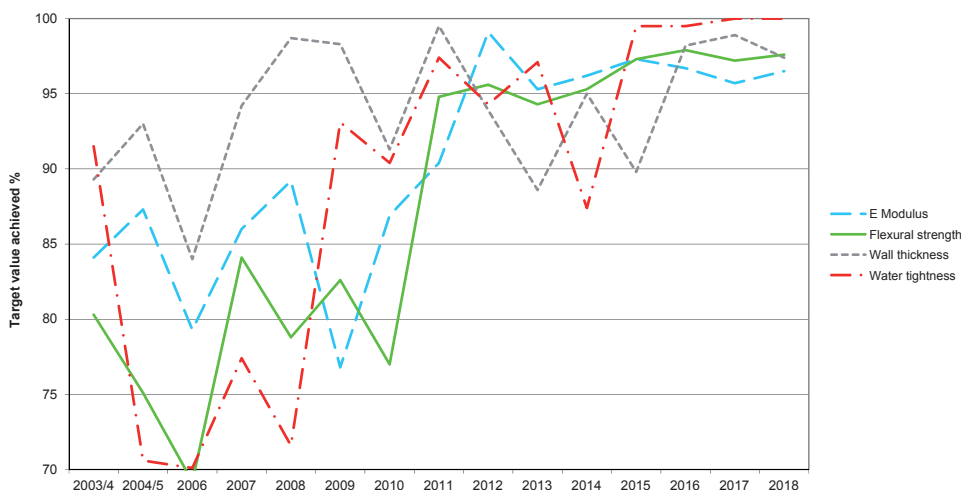
**Figure 3: Proportion of CIPP lining companies that achieved a 100% pass rate for all samples each year.**



**Figure 4: Test results for GRP liners – percentage of samples achieving their target values each year.**



**Figure 5: Test results for needle felt liners – percentage of samples achieving their target values each year.**



**Table 1: CIPP lining company test results for 2018**

		Water tightness		Modulus of elasticity		Flexural strength		Wall thickness	
liner company	liner system	No. of samples	watertight in % of tests	No. of samples	Target value * met in % of tests	No. of samples	Target value * met in % of tests	No. of samples	Target value * met in % of tests
Bluelight GmbH (DE)	PAA-F-Liner	27	100	27	100	27	100	27	100
Hamers Leidingtechniek B.V. (NL)	Alphaliner	97		97		97		97	
ISS Kanal Services AG (CH)	Alphaliner	61		61		61		61	
Jeschke Umwelttechnik GmbH (DE)	Alphaliner	72		72		72		52	
Kanaltechnik Agricola GmbH (DE)	Brandenburger Liner	25***		25		25		25	
Aarsleff Rohrsanierung GmbH (DE)	iMPREG-Liner	71	100	71	100	71	98.6	55	96.4
Aarsleff Rohrsanierung GmbH (DE)	PAA-G-Liner	131	96.9	131	99.2	131	100	58	100
Aarsleff Rohrsanierung GmbH (DE)	PAA SF Liner	149** 25	100	181	98.9	181	100	155	98.7
Arkil Inpipe GmbH (DE)	Berolina Liner	39	100	39	97.4	39	94.9	-	-
Arkil Inpipe GmbH (DE)	iMPREG-Liner	61	95.1	59	98.3	59	98.3	34	94.1
Geiger Kanaltechnik GmbH & Co.KG (DE)	Alphaliner	20	100	32	96.9	32	100	13	100
GMB Rioleringsystemen B.V. (NL)	SAERTEX-Liner	161	99.4	161	98.8	161	96.9	160	99.4
Hubert Wax GmbH & Co. KG (DE)	SAERTEX-Liner	38	100	38	100	38	100	-	-
Insituform Rioolrenovatietechnieken B.V. (NL)	iMPREG-Liner	56***	98.2	56	98.2	56	100	56	60.7
Insituform Rioolrenovatietechnieken B.V. (NL)	Insituform pipe liner (NL)	39**	100	47	85.1	47	87.2	47	91.5
Kanaltec AG (CH)	Brandenburger Liner	34	100	33	90.9	33	87.9	21	100
KATEC Kanaltechnik Müller und Wahl GmbH (DE)	Alphaliner	67	97.0	67	97.0	67	100	30	100
KTF GmbH (DE)	iMPREG-Liner	52	100	56	100	56	98.2	56	98.2
LTS - Lilie Tief- und Straßenbau GmbH (DE)	SAERTEX-Liner	26	100	26	84.6	26	92.3	-	-
Max Bögl Stiftung & Co. KG (DE)	Brandenburger Liner	49	100	56	98.2	56	96.4	19	100
McAllister Bros Ltd. (UK)	iMPREG-Liner	38	97.4	35	100	35	97.1	31	77.4
Rainer Kiel Kanalsanierung GmbH (DE)	SAERTEX-Liner	53	98.1	53	100	53	98.1	25	88.0
Renotec N.V. (B)	Alphaliner	-	-	57	94.7	56	92.9	57	94.7
Renotec N.V. (B)	SAERTEX-Liner	-	-	67	100	67	97.0	65	92.3
RTi Germany GmbH (DE)	SAERTEX-Liner	25	100	26	96.2	26	100	20	100
Swietelsky-Faber Kanalsanierung GmbH (DE)	Brandenburger Liner	40	97.5	40	87.5	40	85.0	24	91.7
TKT GmbH & Co. KG (DE)	Alphaliner	155	100	153	97.4	153	99.3	59	94.9
TRASKO BVT, s.r.o. (CZ)	Alphaliner	78	96.2	78	97.4	78	100	78	92.3
tubus GmbH (DE)	iMPREG-Liner	30***	96.7	30	96.7	30	100	30	86.7
Umwelttechnik und Wasserbau GmbH (DE)	Alphaliner	98	99.0	98	95.9	98	93.9	73	98.6
Umwelttechnik und Wasserbau GmbH (DE)	Brandenburger Liner	145	98.6	144	95.1	144	93.8	78	71.8
<b>mean</b>			<b>98.9</b>		<b>97.5</b>		<b>97.4</b>		<b>94.1</b>

\* Target values determined according to a product approval (DIBt approval, KOMO certificate, QUIK guideline) or customer requirement (static calculation or as stated on sample submission form)

\*\* without cutting the integrated foil

\*\*\* from 4 construction sites

- not evaluated, because too few liner samples supplied with nominal value information

B: Belgium, CH: Switzerland, CZ: Czech Republic, DE: Germany, NL: The Netherlands, UK: United Kingdom

Table 2: CIPP liner system test results for 2018

liner system	Carrier material	Water tightness		Modulus of elasticity		Flexural strength		Wall thickness	
		Number of samples	watertight in % of tests	Number of samples	Target Value* met in % of tests	Number of samples	Target Value* met in % of tests	Number of samples	Target Value* met in % of tests
PAA-F-Liner	NF	27	100	27	100	27	100	27	100
PAA SF Liner	NF	149** 25	100	181	98.9	181	100	155	98.7
Alphaliner	GRP	648	99.1	715	97.8	714	98.5	520	97.5
PAA-G-Liner	GRP	131	96.9	131	99.2	131	100	58	100
SAERTEX-Liner	GRP	303	99.3	371	98.1	371	97.3	277	96.8
iMPREG-Liner	GRP	308	98.1	307	99.0	307	98.7	262	85.5
Berolina Liner	GRP	39	100	39	97.4	39	94.9	-	-
Insituform Schlauchliner (NL)	NF	39**	100	47	85.1	47	87.2	47	91.5
Brandenburger Liner	GRP	293	99.0	298	94.6	298	93.0	167	85.6
mean			98.9		97.5		97.4		94.1

greater than or equal to mean value  
 below mean  
 \* Target values determined according to a product approval (DIBt approval, KOMO certificate, QUIK guideline) or customer requirement (static calculation or as stated on sample submission form)  
 \*\* without cutting the integrated foil  
 - not evaluated, because too few liner samples supplied with nominal value information  
 GRP: Glass Fibre Reinforced Plastic carrier material  
 NF: Needle felt carrier material

Table 3: Test results in 2018 compared to the previous year

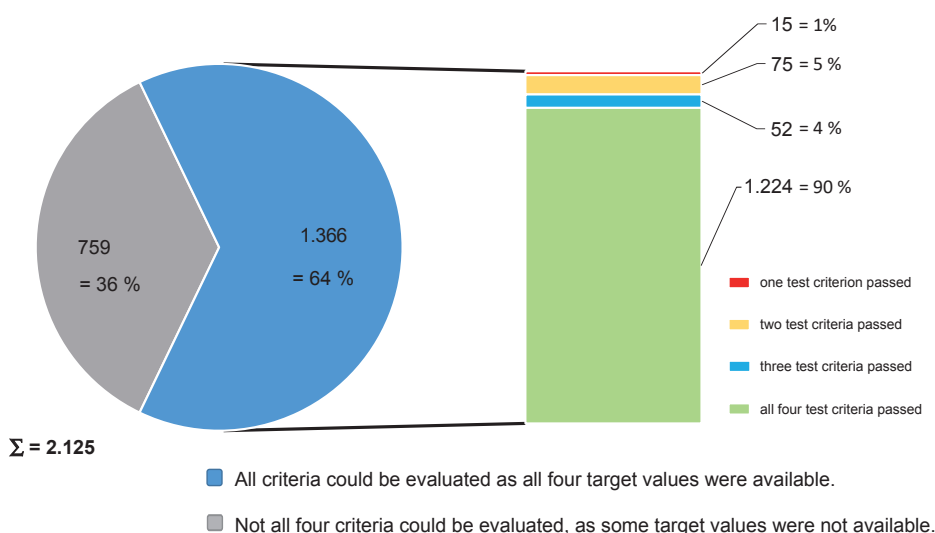
liner type	Water tightness watertight in % of tests			Modulus of elasticity Target value* met in % of tests			Flexural strength Target value* met in % of tests			Wall thickness Target value* met in % of tests		
	2018	2017	+/-	2018	2017	+/-	2018	2017	+/-	2018	2017	+/-
averages												
• of all samples	98.9	99.1	0.2 ↓	97.5	97.4	+ 0.1 ↑	97.4	97.6	- 0.2 ↓	94.1	94.5	- 0.4 ↓
• GRP	98.8	99.0	0.2 ↓	98.0	97.7	+ 0.3 ↑	97.0	97.7	- 0.7 ↓	93.0	93.9	- 0.9 ↓
• NF	100	100	0.0 ↔	96.5	95.7	+ 0.8 ↑	97.6	97.2	+ 0.4 ↑	97.4	98.9	- 1.5 ↓

GRP: Glass Fibre Reinforced Plastic carrier material  
 NF: Needle felt carrier material  
 \* Target values determined according to a product approval (DIBt approval, KOMO certificate, QUIK guideline) or customer requirement (static calculation or as stated on sample submission form)

Figure 6: Summary of the number of samples that passed test criteria in 2018.

### Samples passing all four test criteria

For about two thirds of the liner samples tested by the IKT testing laboratories in 2018, required target values for all four criteria were available. Only if all four target values are known, can a complete evaluation of the sample against all criteria be made. At least one target value was missing for one third of the samples. Of the total of 1,366 samples with all four nominal values, 90% met the requirement for all four test criteria. So, one tenth failed at least one test criterion (Figure 6).







Three-point bending test: mechanical testing of modulus of elasticity and bending strength

### Members of the "100% Club"

Five lining companies managed to achieve a 100% pass for all four test criteria with all their samples in 2018. They are:

- Bluelight GmbH with PAA-F-Liner
- Hamers Leidingtechniek B.V. with Alphaliner
- ISS Kanal Services AG with Alphaliner
- Jeschke Umwelttechnik GmbH with Alphaliner
- Kanaltechnik Agricola GmbH with Brandenburger Liner

Figure 7 shows the "100% Club" stars awarded to each company each year to highlight their performance.

### Conclusions: Preventing loss of quality

The IKT LinerReport has been reflecting the development of quality assurance for CIPP sewer lining since 2003/04. Looking back over the last 15 years, we can see a clear trend of improving quality, over about a decade until 2013/15, before stabilising. Since 2015, there has been a slight tendency for a decline in performance against the mechanical test criteria. Has the long-term improvement in CIPP sewer lining quality assurance ended?

### A sign of declining quality assurance?

This claim seems premature at this time. However, the slightly declining average test results of the last

three to four years indicate that it is not a given that a high level of quality can be maintained once it has been achieved. This could be interpreted as a sign of a possible reversal in the trend. There could be several reasons for this: an intensive struggle by the lining companies for market share in a market that is still very price-competitive, the development of new machinery and plant capacities, the entry of new market participants and, last but not least, the much-discussed shortage of skilled workers, which is particularly noticeable in the commercial sector. Much if this is speculative, so it remains to be seen how the markets develop.

### Sewer network owners must ensure quality assurance

In order to maintain a high level of CIPP liner quality, customers should make it clear to suppliers that quality is important to them and that they take the requirements of the relevant standards and regulations very seriously. In their function as network owners, they should commission independent testing themselves and insist on consequences in the event of negative test results.

Clients should make sure that they have CIPP liner installation checked so that there are no quality loopholes, which can prove to be very expensive in later years. Finally, they should pay much more attention to acceptance warranties, because then they will still have some control in the event of inadequate renovation work.

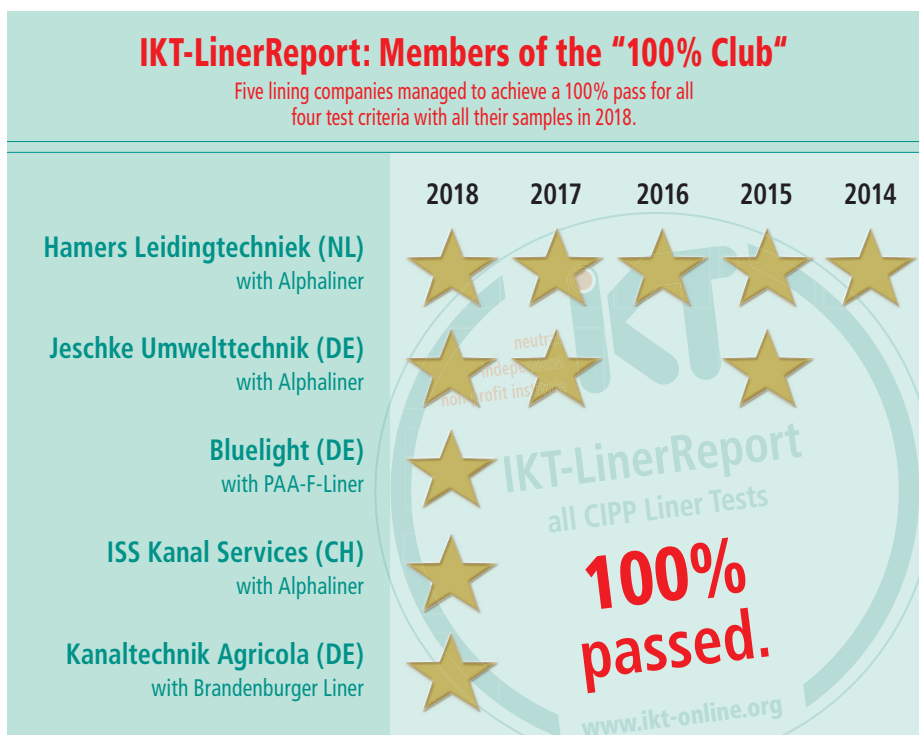


Figure 7: The Star Table for lining companies achieving 100% passes against all four test criteria in recent years.

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