

## Tube liner quality reaches celebratory high level!

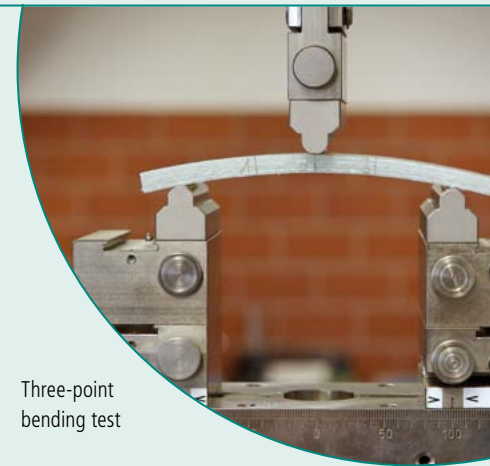
The tube liner's 40th anniversary found the process in top form; the test results for 2011 are a significant improvement over the previous year's level.

2011 was a red-letter year for the tube lining process - one in which it celebrated its 40th anniversary. This "round-figure birthday" was honoured in detail in numerous celebratory addresses and

publications, in which the "tube liner family" proudly highlighted its method as the leading renovation technology for damaged waste-water conduits.

The degree to which claims and reality accorded in this anniversary year is illustrated by the eighth IKT – Institute for Underground Infrastructure LinerReport, presented here. This report

is based on some 2,100 tube liner samples taken from sites during 2011 and analysed at the IKT tube liner test centre.



Three-point bending test

**Table 1: Contractors and liner systems**

Contractors	Liner systems	Liner type	Number of samples	IKT test commissioned by	
				Contractor %	Client %
AKS Umwelttechnik GmbH	Saertex Liner	GRP	51	0	100
Arkil Inpipe GmbH	Berolina Liner	GRP	117	0	100
Arkil Inpipe GmbH	Inpipe Liner	GRP	45	4	96
Diringer & Scheidel Rohrsanierung GmbH & Co. KG	Alphaliner	GRP	84	14	86
Erles Umweltservice GmbH	Impreg Liner	GRP	61	23	77
Fleer-Tech GmbH	RS-CityLiner	NF	48	0	100
Geiger Kanaltechnik GmbH & Co. KG	Berolina Liner	GRP	26	12	88
Hamers Leidingtechniek B.V. (NL)	Alphaliner	GRP	27	100	0
Hertha Ehnes GmbH	Brandenburger Liner	GRP	34*	79	21
Insituform Rohrsanierungstechniken GmbH	Impreg Liner	GRP	115	9	91
Insituform Rohrsanierungstechniken GmbH	Insituform Schlauchliner	NF	181	3	97
Jeschke Umwelttechnik GmbH	Alphaliner	GRP	89	29	71
Jeschke Umwelttechnik GmbH	Brandenburger Liner	GRP	72	0	100
Kanaltechnik Agricola GmbH	Impreg Liner	GRP	42	81	19
Karl Weiss GmbH & Co. KG	Brandenburger Liner	GRP	51	47	53
KATEC Kanaltechnik Müller & Wahl GmbH	Alphaliner	GRP	41	80	20
KMG Pipe Technologies GmbH	Brandenburger Liner	GRP	44*	0	100
KMG Pipe Technologies GmbH	Saertex Liner	GRP	86	0	100
KTF GmbH	Impreg Liner	GRP	26	100	0
Max Bögl Bauservice GmbH & Co. KG	Brandenburger Liner	GRP	91	4	96
Rainer Kiel Kanalsanierung GmbH	Saertex Liner	GRP	146	31	69
Rohr Fuchs Rohrreinigungs GmbH	Impreg Liner	GRP	62	19	81
Rohrsanierung Jensen GmbH & Co. KG	Alphaliner	GRP	36	78	22
Swietelsky-Faber GmbH Kanalsanierung	Brandenburger Liner	GRP	100	0	100
TKT Jens und Lutz Meißner GbR	Alphaliner	GRP	233	9	91
Umwelttechnik und Wasserbau GmbH	Alphaliner	GRP	149	52	48
Van der Velden Rioleringsbeheer (NL)	Impreg Liner	GRP	34	97	3
Win-Line GmbH	Brandenburger Liner	GRP	25	44	56
<b>Total</b>			<b>2,116</b>	<b>22</b>	<b>78</b>

GRP: Glass-fibre backing material | NF: Needle-felt support material | \*from four sites

## Overview of test and inspection criteria

### Modulus of elasticity (short-term flexural modulus)

- Tube liners must be capable of withstanding loads such as those arising from groundwater, road traffic and soil pressure
- The modulus of elasticity is an indicator of load-bearing capability
- Stability may be endangered if modulus of elasticity is too low
- Test method: Three-point bending test as per DIN EN ISO 178 and DIN EN 13 566, Part 4\*
- Results: see Table 2

### Flexural strength (bending stress at rupture = short term- $\sigma_{fb}$ )

- This indicates the point at which the liner fails due to excessively high stress
- If flexural strength is too low, the liner may rupture before the permissible deformation is reached
- Test method: Increase of load up to failure in the three-point bending test; in accordance with DIN EN ISO 178 and DIN EN 13 566, Part 4\* (short-term flexural strength)
- Results: see Table 3

### Wall thickness (mean combined thickness)

- Minimum value is specified in the stress-analysis calculation
- Wall thickness and modulus of elasticity jointly determine the stiffness of the liners
- Excessively low wall thickness can endanger stability
- Test method: Mean combined thickness is measured in accordance with DIN EN 13 566, Part 4\*\*, using a precision slide gauge
- Results: see Table 4

### Water tightness

- A cut is made into the inner film if the latter is not an integral component of the liners; the outer film (if any) is removed
- Water containing a red dye is applied internally
- A 0.5 bar partial vacuum is applied externally
- The liner is „Not tight“ if water penetrates through
- Test period: 30 min.
- Results: see Table 5

\* DIN EN ISO 11296, Part 4 superseded DIN EN 13566, Part 4 with effect from July 2011. The test results were evaluated on the basis of DIN EN 13566, Part 4, however, since the mechanical characteristics data (general building-supervision approvals) were determined on the basis of DIN EN 13566, Part 4.

\*\* The procedure for determination of combined thickness has not been modified in DIN EN ISO 11296, Part 4, vis-à-vis DIN EN 13566, Part 4.

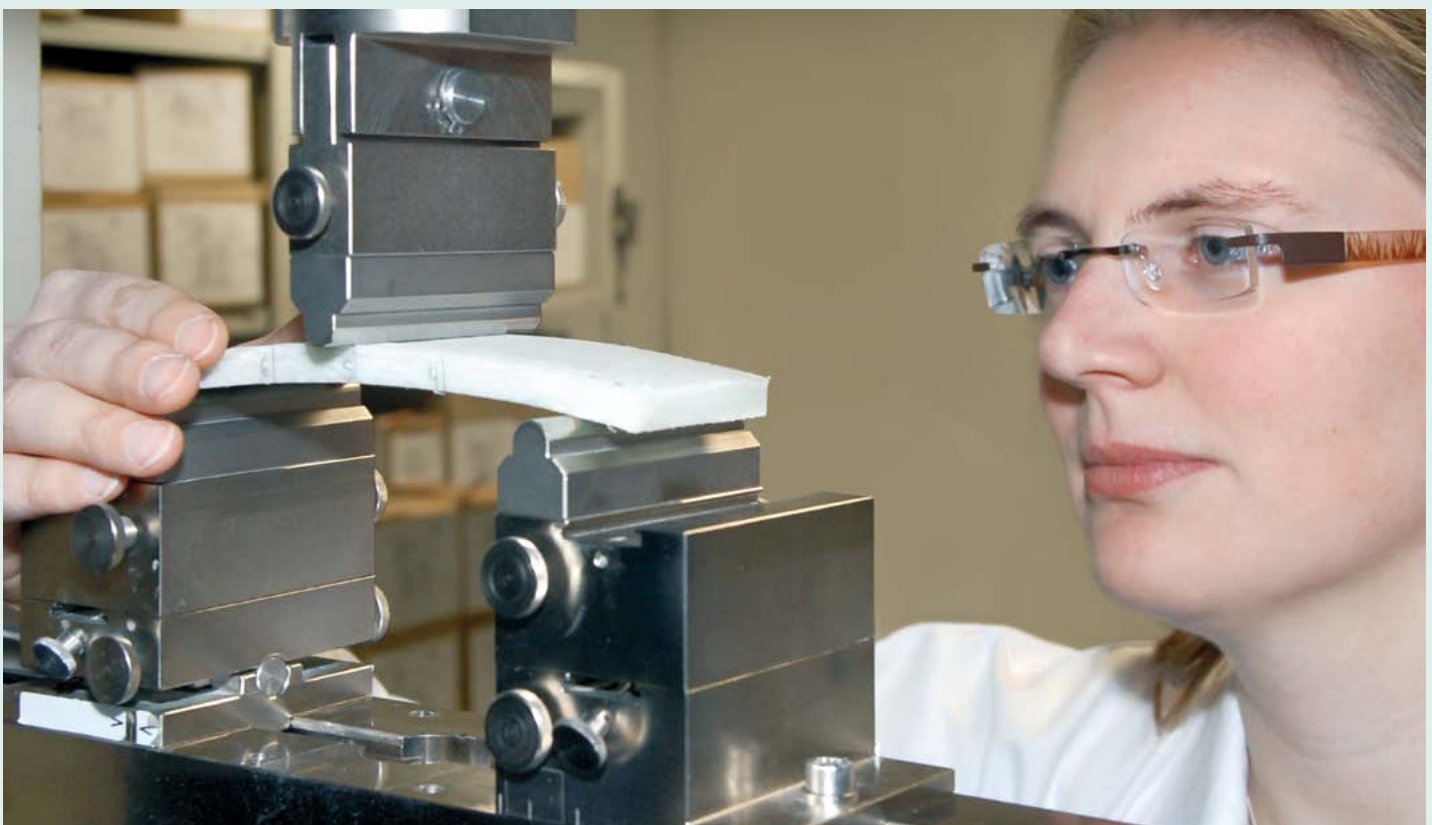
## Data-base

The results obtained by those repair contractors from whom the IKT analysed not less than twenty-five liner samples obtained from five different sites are presented here. This requirement was fulfilled by twenty-four contractors, six more than in the previous year. Two of the contractors work only in the Netherlands, and are indicated by (NL) in the tables.

In 78% of cases, the clients (or their engineering consultancies) commissioned IKT directly for laboratory testing of liner samples, which were taken on site. 22% of the commissions originated from the repair contractors themselves (see Table 1).

## Target/Actual analysis

The characteristics of modulus of elasticity, flexural strength, wall thickness and water-tightness of the tube liner samples taken from construction sites were analysed. The Actual values are compared against the Target data contained in the DIBt (German Institute for Building Technology) approvals, and against any divergent target data provided by the client. The target values for wall thicknesses are specified by means of statics calculations or by the client.



Three-point bending test on a tube liner

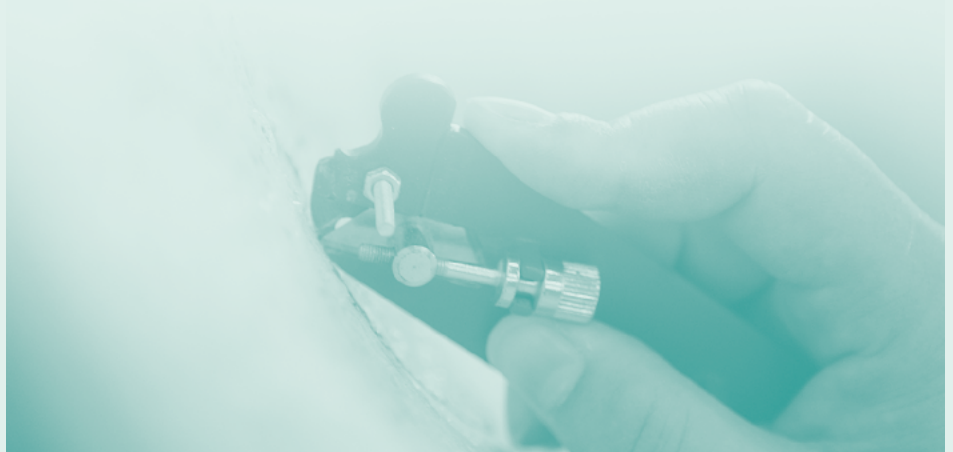
**Table 2: Test results for modulus of elasticity (Short-term flexural modulus)**

Contractors	2011		2010	Trend	
	No. of samples	Target* achieved in % of tests	Target* achieved in % of tests		
Diringer & Scheidel Rohrsanierung GmbH	84	100.0	94.7	↑**	
Erles Umweltservice GmbH	61		100.0	↔	
Geiger Kanaltechnik GmbH & Co. KG	26		–	–	
Hamers Leidingtechniek B.V. (NL)	27		–	–	
Insituform Rohrsanierungstechniken GmbH using the Impreg Liner	115		100.0	↔	
Jeschke Umwelttechnik GmbH using the Brandenburger Liner	72		–	–	
Kanaltechnik Agricola GmbH	42		–	–	
Karl Weiss GmbH & Co. KG	51		100.0	↔	
KATEC Kanaltechnik Müller & Wahl GmbH	41		–	–	
KTF GmbH	25		100.0	↔	
Max Bögl Bauservice GmbH & Co. KG	72		–	–	
Rohr Fuchs Rohrreinigung GmbH	62		98.4	↑	
Rohrsanierung Jensen GmbH & Co. KG	36		–	–	
Swietelsky-Faber GmbH Kanalsanierung	99		98.1	↑**	
Umwelttechnik und Wasserbau GmbH	149		98.7	↑**	
Van der Velden Rioleringsbeheer (NL)	34		–	–	
Win-Line GmbH	25		–	–	
Arkil Inpipe GmbH using the Berolina Liner	117		99.1	100.0	↓
Jeschke Umwelttechnik GmbH using the Alphaliner	89		98.9	100.0	↓
KMG Pipe Technologies GmbH using the Saertex Liner	86		98.8	90.0	↑
TKT Jens und Lutz Meißner GbR	233	98.7	100.0	↓	
<b>Average</b>		<b>98.2</b>	<b>96.8</b>	↑	
AKS Umwelttechnik GmbH	51	98.0	91.8	↑	
KMG Pipe Technologies GmbH using the Brandenburger Liner	44	97.7	–	–	
Rainer Kiel Kanalsanierung GmbH	118	97.5	99.1	↓	
Hertha Ehnes GmbH	34	97.1	–	–	
Arkil Inpipe GmbH using the Inpipe Liner	45	93.3	–	–	
Fleer-Tech GmbH	48	91.7	–	–	
Insituform Rohrsanierungstechniken GmbH using the Insituform-Schlauchliner	181	90.1	97.0	↓	

\* Target values as per client's data (statics / traveller card) | \*\* Different liner system used in 2010 than in 2011 | – Not evaluated, too few liner samples

There are two procedures for testing for water-tightness of needle-felt liners: with and without cutting of the inner film. The latter procedure is used in the case of liners for which the DIBt approval confirms that the inner film is an integral element relevant to tightness. On all other needle-felt liners, the inner film is cut.

GRP liners are in all cases tested without cutting, since they do not feature any inner film which remains in the conduit.



**Table 3: Test results for flexural strength (Short-term- $\sigma_{fb}$ )**

Contractors	2011		2010	Trend
	No. of samples	Target* achieved in % of tests	Target* achieved in % of tests	
AKS Umwelttechnik GmbH	51	100.0	100.0	↔↔
Erles Umweltservice GmbH	61		100.0	↔↔
Fleer-Tech GmbH	48		–	–
Geiger Kanaltechnik GmbH & Co. KG	26		–	–
Hamers Leidingtechnik B.V. (NL)	27		–	–
Hertha Ehnes GmbH	34		–	–
Insituform Rohrsanierungstechniken GmbH using the Impreg Liner	115		100.0	↔↔
Jeschke Umwelttechnik GmbH using the Alphaliner	89		100.0	↔↔
Jeschke Umwelttechnik GmbH using the Brandenburger Liner	72		–	–
Kanaltechnik Agricola GmbH	42		–	–
KATEC Kanaltechnik Müller & Wahl GmbH	41		–	–
KMG Pipe Technologies GmbH using the Saertex Liner	86		97.5	↑
KMG Pipe Technologies GmbH using the Brandenburger Liner	44		–	–
KTF GmbH	25		96.2	↑
Max Bögl Bauservice GmbH & Co. KG	72		–	–
Rainer Kiel Kanalsanierung GmbH	118		100.0	↔↔
Rohr Fuchs Rohrreinigung GmbH	62		98.4	↑
Rohrsanierung Jensen GmbH & Co. KG	36		–	–
Swietelsky-Faber GmbH Kanalsanierung	99		98.1	↑**
Van der Velden Rioleringsbeheer (NL)	34		–	–
Win-Line GmbH	25	–	–	
Umwelttechnik und Wasserbau GmbH	149	99.3	100.0	↓**
TKT Jens und Lutz Meißner GbR	233	99.1	97.4	↑
<b>Average</b>		<b>98.5</b>	<b>96.0</b>	↑
Karl Weiss GmbH & Co. KG	51	98.0	96.3	↑
Arkil Inpipe GmbH using the Berolina Liner	117	95.7	100.0	↓
Diringer & Scheidel Rohrsanierung GmbH	84	95.2	100.0	↓**
Insituform Rohrsanierungstechniken GmbH using the Insituform-Schlauchliner	181	93.4	98.5	↓
Arkil Inpipe GmbH using the Inpipe Liner	45	84.4	–	–

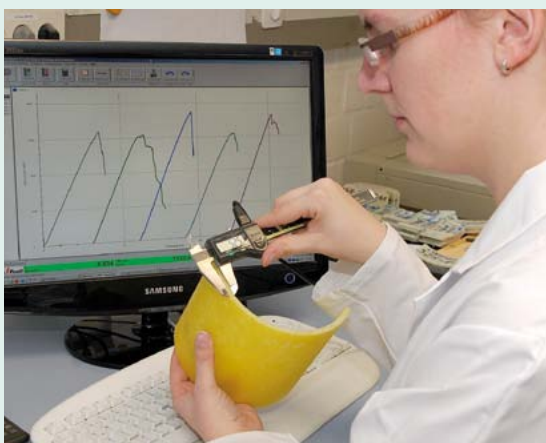
\* Target values as per client's data (statics / traveller card) | \*\* Different liner system used in 2010 than in 2011 | – Not evaluated, too few liner samples



**Table 4: Test results for wall thickness (mean combined thickness in accordance with DIN EN 13566, Part 4)**

Contractors	2011		2010	Trend	
	No. of samples	Target* achieved in % of tests	Target* achieved in % of tests		
Arkil Inpipe GmbH using the Berolina Liner	107	100.0	77.8	↑	
Arkil Inpipe GmbH using the Inpipe Liner	42		–	–	
Hamers Leidingtechniek B.V. (NL)	27		–	–	
Insituform Rohrsanierungstechniken GmbH using the Insituform-Schlauchliner	140		80.0	↑	
Jeschke Umwelttechnik GmbH using the Brandenburger Liner	65		–	–	
Kanaltechnik Agricola GmbH	42		–	–	
KTF GmbH	26		100.0	↔	
Max Bögl Bauservice GmbH & Co. KG	69		–	–	
Rohr Fuchs Rohrreinigung GmbH	53		98.4	↑	
Rohrsanierung Jensen GmbH & Co. KG	36		–	–	
Van der Velden Rioleringsbeheer (NL)	32		–	–	
Swietelsky-Faber GmbH Kanalsanierung	100		99.0	52.7	↑**
Jeschke Umwelttechnik GmbH using the Alphasliner	83		98.8	100.0	↓
Fleer-Tech GmbH	44	97.7	–	–	
Erles Umweltservice GmbH	42	97.6	98.3	↓	
KMG Pipe Technologies GmbH using the Saertex Liner	78	97.4	87.9	↑	
Umwelttechnik und Wasserbau GmbH	130	96.9	88.0	↑**	
Insituform Rohrsanierungstechniken GmbH using the Impreg Liner	31	96.8	88.2	↑	
<b>Average</b>		<b>96.2</b>	<b>89.1</b>	<b>↑</b>	
Karl Weiss GmbH & Co. KG	46	95.7	70.6	↑	
Diringer & Scheidel Rohrsanierung GmbH	60	95.0	100.0	↓**	
TKT Jens und Lutz Meißner GbR	150	93.3	98.2	↓	
KMG Pipe Technologies GmbH using the Brandenburger Liner	28	92.9	–	–	
KATEC Kanaltechnik Müller & Wahl GmbH	35	91.4	–	–	
Hertha Ehnes GmbH	34	91.2	–	–	
Geiger Kanaltechnik GmbH & Co. KG	22	86.4	–	–	
AKS Umwelttechnik GmbH	50	84.0	86.0	↓	
Rainer Kiel Kanalsanierung GmbH	68	80.9	96.6	↓	
Win-Line GmbH	25	80.0	–	–	

\* Target values as per client's data (statics / traveller card) | \*\* Different liner system used in 2010 than in 2011 | – Not evaluated, too few liner samples



Liner-wall thickness is measured using a precision slide gauge



Tightness testing of tube liners



**Table 5: Test results for water-tightness**

Contractors	2011		2010	Trend	
	No. of samples	Target* achieved in % of tests	Target* achieved in % of tests		
AKS Umwelttechnik GmbH	51	100.0	100.0	↔	
Arkil Inpipe GmbH using the Berolina Liner	117		97.8	↑	
Arkil Inpipe GmbH using the Inpipe Liner	44		–	–	
Diringer & Scheidel Rohrsanierung GmbH	84		100.0	↔**	
Geiger Kanaltechnik GmbH & Co. KG	26		–	–	
Hamers Leidingtechniek B.V. (NL)	27		–	–	
Hertha Ehnes GmbH	34		–	–	
Jeschke Umwelttechnik GmbH using the Alphaliner	63		100.0	↔	
Jeschke Umwelttechnik GmbH using the Brandenburger Liner	72		–	–	
Kanaltechnik Agricola GmbH	42		–	–	
Karl Weiss GmbH & Co. KG	51		98.1	↑	
KATEC Kanaltechnik Müller & Wahl GmbH	23		–	–	
KTF GmbH	26		100.0	↔	
Max Bögl Bauservice GmbH & Co. KG	91		–	–	
Rohrsanierung Jensen GmbH & Co. KG	36		–	–	
Swietelsky-Faber GmbH Kanalsanierung	100		98.1	↑**	
Umwelttechnik und Wasserbau GmbH	106		100.0	↔**	
Win-Line GmbH	24		–	–	
TKT Jens und Lutz Meißner GbR	233		99.6	100.0	↓
Insituform Rohrsanierungstechniken GmbH using the Insituform-Schlauchliner, with no cut*	181		99.4	100.0	↓
<b>Using thetelwert</b>			<b>98.9</b>	<b>98.4</b>	↑
Rainer Kiel Kanalsanierung GmbH	146		98.6	100.0	↓
Rohr Fuchs Rohrreinigung GmbH	62		98.4	100.0	↓
Erles Umweltservice GmbH	61	96.7	100.0	↓	
Insituform Rohrsanierungstechniken GmbH using the Impreg Liner	115	96.5	95.6	↑	
KMG Pipe Technologies GmbH using the Saertex Liner	86	96.5	100.0	↓	
KMG Pipe Technologies GmbH using the Brandenburger Liner	44	95.5	–	–	
Van der Velden Rioleringsbeheer (NL)	34	94.1	–	–	
Fleer-Tech GmbH	48	89.6	–	–	

\* With no cutting of integrated inner film/with cutting of the integrated inner film (at the request of the client)

\*\* Different liner system used in 2010 than in 2011 | – Not evaluated, too few liner samples

## Modulus of elasticity and flexural strength at high levels

The repair contractors all achieved extremely good results for the "modulus of elasticity" test criterion in 2011. The vast majority of the samples passed this test without any criticism whatsoever. Even the contractors with below-average test results are nonetheless extremely creditable, and achieve good results in more than 90% of all cases. The average of all tests passed has improved in comparison to the previous year by +1.4 percentage points (%P), to 98.2%. GRP liners improved by +0.8 %P, to 99.2% passed, and needle-felt (NF) liners by +3.5 %P, to 90.4% passed.

The test results for flexural strength are actually even slightly better: the average for all samples is 98.5% (+2.5 %P), the lowest score achieved being 84.4% passed, however. In comparison with the previous year, GRP liners score virtually just as well, at 98.9% passed (-0.3 %P), whereas NF liners have bettered their score by a noteworthy +17.8 %P, to 94.8%.

## Wall thickness significantly improved

In the past, wall thickness has been the test criterion in which GRP liners regularly performed more poorly than NF liners. This remains the case in 2011, but on the basis of a significantly higher average score of 96.2% (+7.1 %P) achieved by all samples. Both GRP and NF liners have improved significantly compared to the previous year, by +7.1 %P, to 95.8%, and by 8.2 %P, to 99.5%, respectively.

## Water-tightness nearly 100%

The score for water-tightness reaches a previously unattained 98.9% passed (+0.5 %P) on average. GRP liners remain unchanged at 99.1% tight of all cases, whereas NF liners have made a mighty leap forward, by a remarkable +7.0 %P, to 97.4%. The number of contractors achieving tightness in 100% of cases is again pleasingly high: no less than eighteen contractors supplied samples which achieved perfect tightness. Leaks are now also the exception for the other contractors, however, who diverged only very seldom from the top score.

**Table 6: Test results by liner type**

	Water-tightness		Modulus of elasticity		Flexural strength		Wall thickness	
	No. of samples	Target* achieved 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
Linear system								
Brandenburger Liner	416	99.5	397	99.5	397	99.7	367	96.5
Impreg Liner	340	97.4	339	100.0	339	100.0	226	99.1
Berolina Liner	143	100.0	143	99.3	143	96.5	129	97.7
Alphaliner	572	99.8	659	99.4	659	98.9	521	96.0
Inpipe Liner	44	100.0	45	93.3	45	84.4	42	100.0
Insituform Schlauchliner	181	99.4	181	90.1	181	93.4	140	100.0
RS CityLiner	48	89.6	48	91.7	48	100.0	44	97.7
Saertex Liner	283	98.2	255	98.0	255	100.0	196	88.3
<b>Average</b>		<b>98.9</b>		<b>98.2</b>		<b>98.5</b>		<b>96.2</b>

above the average

below the average

\* Target values according to client's data (statics / traveller card)

**Table 7: Test results compared to results for previous year**

Liner type	Watertight 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		
	2011	2010	+/-	2011	2010	+/-	2011	2010	+/-	2011	2010	+/-
<b>Averages</b>												
of all samples	98.9	98.4	+0.5 ↑	98.2	96.8	+1.4 ↑	98.5	96.0	+2.5 ↑	96.2	89.1	+7.1 ↑
GRP	99.1	99.1	±0.0 ↔	99.2	98.4	+0.8 ↑	98.9	99.2	-0.3 ↓	95.8	88.7	+7.1 ↑
NF	97.4	90.4	+7.0 ↑	90.4	86.9	+3.5 ↑	94.8	77.0	+17.8 ↑	99.5	91.3	+8.2 ↑

GRP:Glass-fibre backing material

NF:Needle-felt backing material

\* Target values as per client's data (statics / traveller card)

## Conclusion

The test results obtained for 2011 by the IKT tube liner test centre demonstrate that water-tightness is, pleasingly, no longer a serious problem for tube liners. This was not the case in the past, and shows that the repair contractors take the subject of tightness very seriously, and have significantly improved their products and procedures. The same also applies to the mechanical test results, which have also followed an upward trend, with major leaps in some cases.

The needle-felt liners, which have in some cases fallen significantly behind the GRP liners in recent years, have achieved a considerable feat of catching up. Comparison against the previous year's results indicates that both GRP and NF liner manufacturers have worked on eliminating their respective weaknesses.

Despite tough price competition on the repair market, obviously no downward quality spiral has occurred, but rather the opposite, with achievement of improved on-site results. This positive trend may be attributed primarily to the heightened quality awareness of clients, who now have every tube liner project inspected and sampled, and insist on corresponding improvements in case of non-conformities. Ultimately, the publication of the test results will also have led to greater market transparency and comparability, and thus have increased the pressure for improvements in materials and in procedures.

It can, all in all, be ascertained that tube liners have achieved in 2011 a high quality level appropriate to their 40th anniversary celebrations. Our warmest congratulations!

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