Withstanding the pressure: liners for pressure sewers put to the test

Aging pressure sewer pipes, just like gravity sewers, require renovation. But which methods are best suited for the job? What are the pros and cons of each? The latest IKT comparative product test on pressure sewer liners offers valuable insights.

Experimental setup of pressure sewer pipes in the IKT large 1:1 scale test facility

Pressure sewers are critical and sensitive elements of urban wastewater infrastructure. Many are ageing so sewer network owners are

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thods available on the market for this.

Consequently, the neutral, independent and not for profit IKT Institute for Underground Infrastructure, in Germany, has been examining rehabilitation solutions in an extensive comparative product test. Over a three-year period an evaluation project was undertaken on behalf of six municipal network operators from Bottrop, Bremen, Burscheid, Iserlohn, Cologne and Voerde and two regional water associations, the Emschergenossenschaft and the Wupperverband.

The project was supported by the district government of Münster and the State Office for Nature, Environment and Consumer Protection of North Rhine-Westphalia (LANUV). It was financed jointly by the NRW Ministry of the Environment and the eight network operators.

These organisations formed a steering group that determined the pressure sewer damage scenarios to be remedied, the testing programme and the evaluation of the results. IKT developed the test concept, set up the test rigs in its large 1:1 scale test pit and carried out the testing.

Six liners in the comparative product test


View of the built-in sewer pressure pipelines in the IKT large 1:1 scale test facility

The steering committee selected the following lining technologi

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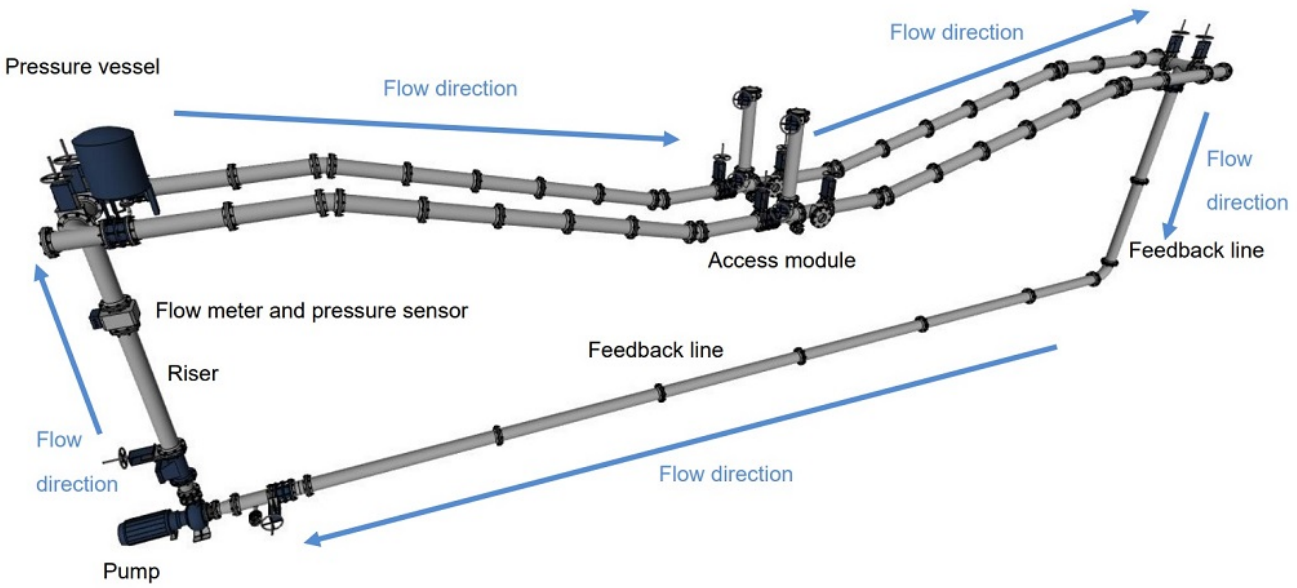
Close-fit linier method:

- Compact Pipe (Wavin GmbH)
- egeLiner (egeplast international GmbH)

Cured in Place Pipe (CIPP) liner process:

- Esders HPS Liner (Esders Pipeline Service GmbH)
- Nordiflow WPE (NordiTube Technologies SE)
- SaniPipe (AMEX Sanivar AG)
- Starliner Structure-S (Karl Weiss Technologies GmbH)

Remediation task



Schematic representation of the test setup in the IKT large 1:1 scale test facility

For each liner system, the test setup consisted of a DN200 steel pipe with damage patterns such as holes, leaky connections, point loads, transverse and longitudinal cracks, ovalisation and incrustations. This realistically depicted the damage that network operators find in their pipes.

Class A liner systems

The central issue was whether the liners are suitable as Class A products. A Class A liner must be able to withstand internal and external stresses on its own, regardless of the condition of the host pipe. The stress testing programme conducted as part of the IKT comparative product test went well beyond the regular warranty period of five years in order to consider the entire useful life.

Test program and evaluation scheme

Simulation of external water pressure: After flooding, part of the test setup is reflected in the water

The test programme consists of three phases: The first phase depicted the regu lar, normal operation of a rehabilitated pressure pipe. Internal water pressure s of between 2 and 6 bar were applied at different flow speeds.

In the second phase, the degeneration of the host pipe was simulated over a prolonged period of time. For this purpose, some of the damage scenarios in the host old pipe were worsened in order to simulate progressive damage development and the resulting changes in external influences on the liner. Test pressures and flow rates remained the same as in the first phase.

Finally, the third phase served to simulate additional, non-every day and extraordinary loads on the liner that may occur over the course of its useful life. These included high-pressure cleaning at 80 bar, abrasive substances, the rapid switching on and off of the pump or elevated groundwater levels, such as those that occur when pipes pass under rivers.

Evaluation criteria

Examination of the renovation results in the IKT large 1:1 scale test facility

The overall grades for the liner syst

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ty and quality assurance. These are divided into nine sub-criteria. The range of grades lies between VERY GOOD (1.0) and INADEQUATE (6.0).

Watertightness criterion (weighting 45%)

The main weak points found in the four CIPP liner processes were the end connections to the host pipe, there were leaks. In contrast, the PE flange and electrofusion sleeve connections of the close-fit liners were reliably watertight.

The close-fit systems Compact Pipe and egeLiner proved to be watertight after renovation. In contrast, the picture for the CIPP liner end connections was very different: Nordiflow and

SaniPipe each had to be reworked once to make them all watertight, whilst the Starline end connections had to be reworked twice in order to get them tight. The Esders HPS liner remained leaky even after the connections had been repaired twice and thus it failed on this criterion.

Stability criterion (weighting 25%)

Optical inspection of rehabilitated sewage pressure lines in the IKT large 1:1 scale test facility

The stability (load-bearing capacity of the structure) wa s classified by the steering committee as a central “KO” (failure) criterion. I

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with GOOD or SATISFACTORY grades. They show no or only minor abnormalities such as lo cal wrinkling.

The SaniPipe liner failed this criterion as it collapsed under external pressure. The reason for this was insufficient fabrication of the liner, which took place without static proof. It was therefore not a Class A liner and consequently received the overall rating INADEQUATE, regardless of performance against all other criteria.

Operational performance criterion (weighting 15%)

This examined to what extent the liners can withstand normal operating conditions such as pressure fluctuations, abrasion, static pressures and high-pressure cleaning.

Here, Compact Pipe and egeLiner

Clearly recognisable longitudinal fold in an installed liner scored a GOOD grade. Also, they did not form folds and obstacles along their le ngth. However, their installation leads to a hydraulic loss of 6% compared to unli ned pipe this was in the middle range. The Nordiflow and Starline liners both had folds larger than 6 mm in the installed liners sheets and thus achieved a SATISFAC

TORY score. However, the hydraulic power loss of the Nordiflow was particular ly high at 8%, whilst the Starline was the lowest at 3%.

With high-pressure cleaning, the Compact Pipe and egeLiner close-fit products achieved a VERY GOOD rating. Nordiflow and Starline withstood this operational stress SATISFACTORILY. On the other hand, Esders and SaniPipe failed this criterion because holes and delaminations occurred. Chemical loads did not have a negative effect on any liner system.

Quality assurance criterion (weighting 15%)

Although all the manufacturers provided an installation procedure manual, some of them have significant deficits in training, test certificates and external and internal monitoring. In addition, the installed Esders and SaniPipe liners each had a continuous longitudinal fold along the length and SaniPipe had design defects, which led to a devaluation of the grade.

Overall result and conclusion

The IKT comparative product test “Renovation process for sewage pressure pipes – Class A liner” confirmed that it is possible to achieve good renovation results. However, there are major differences in the performance of the six rehabilitation technologies examined, which are reflected in the test results awarded. One of the six liners could not qualify as a Class A liner.

IKT - Institute for Underground Infrastructure

Overall Results: IKT–Comparative Product Test (IKT – Warentest) "Rehabilitation methods for wastewater pressure pipes - Class A liner".

Task:
Rehabilitation of an approx. 22 m long steel pipeline DN 200 with the following damage scenarios:
Leaking joints (4x), pitting (2x - with condition deterioration), single hole 48 mm (2x), shear load (with condition deterioration), longitudinal cracks (with condition deterioration), 15°, leaky bend (2x - with condition deterioration), abrasion in the invert, axially displaced socket joint, single hole 8/48 mm (2x - with condition deterioration), ovalisation by 6 %, double overlapping hole 2x 48 mm (optional), transverse cracks with angulation (optional), incrustation (optional), maximum rehabilitable bend (optional).

System		Compact Pipe	egeLiner	Nordiflow W PE	Starline Structure-S	Esders HPS Liner	SaniPipe
Manufacturer		Wavin GmbH	egeplast international GmbH	NordiTube Technologies SE	Karl Weiss Technologies GmbH	Esders Pipeline Service GmbH	Amex Sanivar AG
Renovation company undertaking installation		Diringer & Scheidel Rohrsanierung GmbH & Co. KG	Esders Pipeline Service GmbH	Esders Pipeline Service GmbH	Karl Weiss Technologies GmbH	Esders Pipeline Service GmbH	Amex Sanivar AG
IKT - Test Rating*		**GOOD 1.8**	**GOOD 1.8**	**SATISFACTORY 2.6**	**SATISFACTORY 2.6**	**DEFICIENT 5.3**	**INADEQUATE 6.0**[1]
Statically independent class A liner? (knock-out criterion)		**yes**	**yes**	**yes**	**yes**	**yes**	**no** Not usable as class A liner due to system collapse
Watertightness[2] Devaluation due to rework after installation	**45%**	**1.0** none	**1.0** none	**2.0** Tight only after 1x rework[3] (-1.0)	**3.0** tight only after 2x rework[3] (-2.0)	**6.0** Leaky even after 2x rework[3]	**3.4** tight only after 1x rework[3] (-1.0)
Exfiltration watertightness	80%	1.0	1.0	1.0	1.0	5.0	2.8
Infiltration watertightness	20%	1.0	1.0	1.0	1.0	1.0	1.0
Stability	**25%**	**3.0**	**3.0**	**3.2**	**2.0**	**5.4**	**6.0**
Load bearing capacity of the structure	50%	2.0 Deformations in the bend	2.0 Deformations in the bend	4.0 Wrinkles in the bend, holes, air pockets	2.0 Wrinkles in the bend	5.0 Continuous longitudinal fold, wrinkles in the bend, holes, risk of failure	6,0 Continuous longitudinal fold, wrinkles in the bend, holes, risk of failure, system collapse
Static proof	30%	4,5	4,0	2,5	2,0	5,5	6,0
Material and geometry target/actual comparison	20%	3.0 2 Deviations	4.0 3 Deviations	2.0 1 Deviation	2.0 1 Deviations	6.0 6 Deviations	6.0 6 Deviations
Operational performance	**15%**	**2.3**	**2.4**	**3.3**	**2.7**	**4.1**	**4.5**
Overall visual impression after refurbishment, HP cleaning and end of testing	25%	1.0	1.0	3.4	2.7	5.0	4.7
Hydraulic performance loss after renovation in percent[4]	25%	3.0 - 6%	3.0 - 6%	4.0 - 8%	2.0 - 3%	3.0 - 5%	4.0 - 8%
Wrinkling / Obstacles	25%	1.0 none	1.0 none	3.0 > 6 mm in bend	3.0 > 6 mm in bend	5.0 > 6 mm in liner section & bend	5.0 > 6 mm in liner section & bend
Cross-section reduction of the host pipe DN 200: max. ball passage line / bend / connection	25%	4.3 160 / 155 / 160 mm	4.5 160 / 155 / 155 mm	3.0 180 / 170 / 155 mm	3.0 180 / 160 / 160 mm	3.3 170 / 170 / 160 mm	4.3 160 / 160 / 155 mm
Quality assurance Procedures manual, training, test certificate, monitoring, special anomalies	**15%**	**1.5**	**1.5**	**2.5**	**2.5**	**4.5** Continuous longitudinal fold	**5.5** Continuous longitudinal fold and execution defects
Additional information Not part of the grade							
Robustness: shard load, metal tip (double overlapping hole), incrustation, angular deflection, maximum bend		o | - | + | + | 22.5°	+ | - | - | + | 22,5°	+ | + | - | + | 15°	+ | + | + | + | 30°	o | + | + | + | 30°	o | + | + | + | 30°
Wall structure		PE pipe SDR17 PN10 PE100	PE pipe SDR17 PN10 PE100-RC	Preliner + GRP-reinforced needle felt + inner foil	Preliner + laminate with glass fibres + fabric sleeve + inner foil	Outer foil + laminate with needle felt + fabric hose + inner foil	Outer film + felt fabric and polyester fibres with resin casting + inner film
Wall thickness		approx. 13.4 mm	approx. 13.5 mm	approx. 4.9 mm	approx. 6.3 mm	approx. 7.3 mm	approx. 7.7 mm
Installation procedure		Close-fit insertion method	Close-fit insertion method	Inversion method with preliner	Inversion method with preliner	Insertion/Inversion Process	Insertion/Inversion Process
Curing method and time		Steam (120 C°), approx. 2 h	Steam (130 C°), approx. 1.5 h	Steam (80 C°), approx. 3.5 h	Hot water (40 C°), approx. 19 h	Steam (100 C°), approx. 1.5 h	Steam (80 C°), approx. 22 h
Connection type		PE flange/ electrofusion socket	PE flange / electrofusion socket	Amex liner end cuff	Kempe liner end sleeve	Amex liner end cuff	Amex liner end cuff
Total working time / days on site		14.5 h / 2 days	15.5 h / 3 days	15.5 h / 3 days	11.5 h / 2 days	11 h / 2 days	14.5 h / 4 days

[1] Due to system collapse, the IKT test rating of "INADEQUATE 6.0" was awarded by the Steering Committee independently of the other sub-ratings.
[2] For the difference in the evaluation of exfiltration and infiltration watertightness, see chapter 4.2, page 31.
[3] Rework on liner end seals
[4] Does not serve as a dimensioning reference.
*Note calculation based on unrounded values

Evaluation key of the test results: Very good = 1.0 - 1.5. Good = 1.6 - 2.5. Satisfactory = 2.6 - 3.5. Sufficient = 3.6 - 4.5. Deficient = 4.6 - 5.5. Inadequate = 5.6 - 6.0

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IKT-Comparative Product Test –Rehabilitation methods for wastewater pressure pipes

Table of results IKT comparative product test “Renovation of sewage pressure pipes”

Passed:

- Compact Pipe (Wavin) GOOD (1.8)

- egeLiner (egeplast international) GOOD (1.8)
- Nordiflow W PE (NordiTube Technologies) SATISFACTORY (2.6)
- Starline Structure-S (Karl Weiss Technologies) SATISFACTORY (2.6)

Failed:

- Esders HPS Liner (Esders Pipeline Service) DEFICIENT (5.3)
- SaniPipe (Amex Sanivar) INADEQUATE (6.0)

Results at a glance and complete report (English)

The further deterioration of the condition of the host pipe over time was found to have no effect on the success of the rehabilitation. This applied in particular to signs of corrosion such as simulated pitting and point loads. Only in one case did the complete loss of the supporting host pipe lead to liner failure under external water pressure.


30° bend in a pressure sewer pipeline

All six of the liner systems co

uld be installed through the four 15° bends included in the rig. Three of the li ners were even able to install through a further 30° bend.

The systems were able to withstand normal operating conditions such as pressure fluctuations, abrasion and static pressure without any problems. However, there are clear limits to high-pressure cleaning and holes and delamination can occur here. Chemical stresses did not affect the tightness of the liner.

All liner systems lead to hydraulic performance losses in the pressure sewer the highest up to 8% at the top. The internal diameter was reduced by more than 20% in some places in some liners. Wrinkles >6 mm could be seen on all the CIPP liners. In contrast, the close-fit liners showed no creasing whatsoever, but there was clear ovalisation in the bends.