The contestants are close on the heels of the test winner of 2005. In the first IKT product test of house connection liner five years ago, a clearer advantage of the test winner BRAWOLINER appeared in the competition. The latter did not only watch but rather has considerably improved its products in the meantime. Now (almost) all lie WELL at the same level. Only one needs to catch up somewhat, is a prototype however.

Liner in the test
A steering committee consisting of 17 municipal representatives accompanied the product test over the entire project duration. It also made the decision for the liner selection, among others. Only bend-capable liner products were used.

Test installation
In test lines in the IKT large scale test facility, typical damage patterns such as longitudinal and transverse cracks, fragments and missing pipe pieces were reproduced. Two damage scenarios were constructed (cf. Tab. 2):
- **Standard situation**: Minimum requirements for bend-capable liners
- **Extreme situation**: Increased requirements through material and nominal width change

Evaluation criteria
The system tests in the test lines (weighting 80%) as well as the quality assurance of the procedure supplier (weighting 20%) were evaluated. Evaluation criteria of the system test were functionality, water tightness, load-bearing capacity as well as the sensitivity to buoyancy.

Test results of standard situation
In the standard situation, four out of five liners show GOOD performances: BRAWOLINER XT, LineTEC ProFlex Liner, DrainLiner and RS Max-Liner FLEX S. Among the system tests weighted with 80%, all four show an equally high level (GOOD). In the quality assurance (20% weighting), they achieve VERY GOOD rating.

---

**Tab. 1: Liners in the IKT product test house connection liner 2010**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Liner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karl Otto Braun GmbH &amp; CO. KG</td>
<td>BRAWOLINER XT</td>
</tr>
<tr>
<td>RS-Technik AG</td>
<td>RS MaxLiner-FLEX S</td>
</tr>
<tr>
<td>Trelleborg Pipe Seals Duisburg GmbH</td>
<td>DrainLiner</td>
</tr>
<tr>
<td></td>
<td>DrainPlusLiner</td>
</tr>
<tr>
<td></td>
<td>epros®DrainGlassLiner (Prototyp)</td>
</tr>
<tr>
<td></td>
<td>epros®DrainPlusGlassLiner (Prototyp)</td>
</tr>
<tr>
<td>Vereinigte Filzfabriken AG</td>
<td>lineTEC ProFlex Liner</td>
</tr>
</tbody>
</table>

**Tab. 2: Test installation in the IKT large-scale test facility**

<table>
<thead>
<tr>
<th>Standard situation (= Minimum requirement for liners)</th>
<th>Extreme situation (= Maximum requirement on liner)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitrified clay ND 150</td>
<td>Vitrified clay ND 125 and ND 150</td>
</tr>
<tr>
<td>Material and nominal widths are uniform</td>
<td>PVC ND 125</td>
</tr>
<tr>
<td>no change in dimension</td>
<td>Dimension change ND 125 to ND 150</td>
</tr>
<tr>
<td>no material change</td>
<td>Material change PVC to vitrified clay</td>
</tr>
<tr>
<td>8 Bends</td>
<td>12 Bends</td>
</tr>
<tr>
<td>21 Damages</td>
<td>22 Damages</td>
</tr>
<tr>
<td>Rehabilitation through revision opening</td>
<td>Rehabilitation through 90°-bends</td>
</tr>
</tbody>
</table>
The epros® DrainGlassLiner that entered into the race as prototype falls compared to the group of four and comes altogether to the overall grade ADEQUATE. Although it is bonded clearly stronger than the competitors with the old pipe, which however leads to significantly higher fracture risks under buoyancy load by ground water. Moreover, as a prototype it still lacks technical approval by the Deutsches Institut für Bautechnik (German Institute for Construction Technology, a government body, German abbreviation: DIBT) and environmental impact certificates.

**Test results, extreme situation**
In the much more demanding extreme situation, the BRAWOLINER XT qualifies best (VERY GOOD) and thus remains at the same achievement level as in the previous product test of 2005.

The other four liners follow it: DrainPlusLiner, lineTEC ProFlex Liner, RS MaxLiner FLEX S and the prototype epros® DrainPlusGlassLiner. In system test (80% weight), they are all GOOD. Only in quality assurance (20% weight), does the prototype fall because it lacks DIBT approval and UVP certification. Therefore, it attains a strong SATISFACTORY while the remaining three finished with GOOD.

**Clear improvement in functionality**
Even in bends and offsets, the products hardly showed considerable fold formation. Here there were clear visible improvements compared to earlier test results. Clogging dangers are hardly expected or not at all.

**All liners are tight in strand test**
In the air pressure test according to DIN EN 1610 all liners proved to be water tight. Even after simulated operation loads by 5-fold high-pressure cleaning and isolated chain spining, the tested liners remained watertight. Therefore, they fulfill the legal and normative tightness requirements as far as they are correctly incorporated.

**Weakness laminate**
The characteristics guaranteed in the DIBt approval of the laminates with respect to tightness and minimum wall thickness were not fulfilled a multiple times. More than one-fifth of the laminate test spots did not pass the water tightness test according to APS because the laminate was permeable to water.

Nevertheless, the liners were altogether water-tight in the strand test. Apparently, the installation foil and/or adhesion to the old pipe assume the sealing function.

**Resin leakage at damaged points**
Especially at extensively damaged spots and leaky sockets, considerable quantities of liner resin leaked apparently uncontrolled into the ground. A thinner wall thickness is to be reckoned with at these points. Tightness and load-bearing capacity were characterised by the composite behaviour between liner material, resin leakage as well as old pipe and ground.

**Buoyancy risks due to ground water rise**
Some liners feature a goal conflict: In order to avoid seepage, they must be bonded strongly with the old pipe. A good adhesion entails, however, an increased fracture risk, namely then, when it comes to the buoyancy through ground water.

Infiltration measurements showed that the cracks in liner material can again lead to extreme infiltration quantities under outside water pressure where appropriate resulting in negligible hence in the liner material that question the rehabilitation goal - infiltration tightness.

**High demands on execution**
In the installation for the product test, it appeared that the execution on site required technical understanding and skill. This concerns above all the rehabilitation preparations such as cleaning and milling machine tasks as well as soaking on the spot.

**Quality supervision necessary on the spot**
The test results show that relevant quality characteristics could be examined in the test in detail, however are hardly understood on the spot. This applies especially to the recognition of later weaknesses under outside water pressure, verification of laminate tightness as well as measurement of wall thickness distribution over the pipe strand surface.

**Conclusion**
In the entire view, the IKT product test „tube liners for lateral pipes“ shows that the rehabilitation of defective house connection lines with the tube lining procedure also functions in difficult line routing. This applies to the seal against exfiltration. The tested liner systems are GOOD throughout.

Somewhat different in approach is the situation with infiltration rehabilitation. Buoyancy risks caused by rising ground water occur in this case as consequence of the extensive line sealing. The buoyancy risks can lead to pipe movements and this to liner fractures. So that this does not happen, an integrated rehabilitation planning is called for, which considers the ground water level.

**Results available on the Internet**
The article represents the results of the IKT product test only in excerpts. The complete research report is on the Internet ready for download: [www.ikt.de](http://www.ikt.de)

**Author**
Dipl.-Ing. (FH) Kathrin Harting
IKT - Institute for Underground Infrastructure

(Result tables on the following pages)
Table 3: IKT product test „tube liners for lateral pipes“

**Standard situation**

Rehabilitation of three connection sewage lines made of vitrified clay ND 150; correct connection with a connection pipe above the abutment of the main pipe; inversion with PVC KG revision openings at the beginning of the vitrified clay sewage line; bends: 45° and 30°; introduced damages: longitudinal cracks, transverse cracks, fragment formation, missing pipe pieces, improperly fabricated inlet, leaky pipe connections, fat deposits.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Tube liner</td>
<td>BRAWOLINER XT</td>
<td>SinTEC ProfiFlex Liner</td>
<td>RS MixLine+/FLEX S</td>
<td>Drain Liner</td>
<td>express® DrainLine liner (Prototype)</td>
</tr>
<tr>
<td>Used substrate material</td>
<td>Polyester fibre tube with polyester onethane film</td>
<td>Polyester fibre tube with polyester onethane film</td>
<td>Polyester fibre tube with polyester onethane film</td>
<td>Polyester needle felt tube with polyurethane film</td>
<td>Polyester needle felt tube/OCR glas with polyester fibre film</td>
</tr>
<tr>
<td>System test (weighting 80%)</td>
<td>System test (weighting 80%)</td>
<td>System test (weighting 80%)</td>
<td>System test (weighting 80%)</td>
<td>System test (weighting 80%)</td>
<td>System test (weighting 80%)</td>
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<td>Polyurethane film</td>
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<tr>
<td>Load-bearing capacity of structure (20%)</td>
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<td>3.1</td>
<td>4.6</td>
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<td>Laminate test (10%)</td>
<td>4.4</td>
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<td>Outside water pressure (15%)</td>
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<tr>
<td>Sensitivity under buoyancy (10%)</td>
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<tr>
<td>Quality assurance (weighting 30%)</td>
<td>very good (1.0)</td>
<td>very good (1.0)</td>
<td>very good (1.0)</td>
<td>very good (1.0)</td>
<td>poor (5.5)</td>
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</tbody>
</table>

**Recommended improvements**

- Solving target conflict between adhesion and offset possibility under buoyancy. Strong adhesion led in two test stretches to buoyancy damages.
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Table 4: IKT product test „tube liners for lateral pipes“

**Extreme situation**:

Rehabilitation of three connection sewages made of vitrified clay and PVC-KG of nominal width ND 125 and ND 150; correct connection with a connection pipe in the abutment of the main tube; inversion through a vitrified clay bend 90° ND 125 at the beginning of the stone sewage; bends: 45°, 30° and 15°; introduced damages: longitudinal cracks, transverse crack, fragment formation, missing pipe pieces, improperly fabricated material change vitrified clay on PVC KG, improperly fabricated nominal change ND 125 on ND 150, leaky pipe connections, fat deposits.

### IKT - Test assessment: Extreme situation

1. **System test (weighting 80%)**
   - **Functional capability**
     - Polyester fibre tube with polyester urethane film: 2.1
     - Polyester needle felt tube with polyurethane film: 2.0
   - **Tightness (60%)**
     - After alcoholisation (30%)
       - Polyester fibre tube: 1.0
       - Polyester needle felt tube: 1.0
     - After HF-cleaning (10%)
       - Polyester fibre tube: 1.0
       - Polyester needle felt tube: 1.0
     - Laminating test (10%)
       - Polyester fibre tube: 1.0
       - Polyester needle felt tube: 1.0
   - **Load-bearing capacity of structure (20%)**
     - Composite thickness of polyester fibre tube: 3.0
     - E-Module of polyester fibre tube: 4.0
     - Distortion breaking strength of polyester needle felt tube: 100,000 kgf
   - **Sensitivity under buoyancy**
     - Risk conceivable:
       - Polyester fibre tube: 1.0
       - Polyester needle felt tube: 1.0
   - **Quality assurance (weighting 20%)**
     - DIBt-certification: yes
     - Environmental impact certificates of the resin presented: yes

### Tube liner

<table>
<thead>
<tr>
<th>Supplier</th>
<th>BRAWOLINER XT</th>
<th>DrainPlusLiner</th>
<th>lineTEC ProFlex Liner</th>
<th>RS-Technik AG</th>
<th>Trelleborg Pipe Seals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liner supplier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester fibre tube</td>
<td></td>
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<td></td>
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<tr>
<td>with polyester urethane film</td>
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</tr>
<tr>
<td>Polyester needle felt tube</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>with polyurethane film</td>
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</tr>
</tbody>
</table>

### Risk conceivable

1. **Constitution atlas investigation**
   - Practice friendly installation
   - Practice friendly installation
   - Practice friendly installation
   - Practice friendly installation

### Additional information

- Available for ND 100 to ND 200
- Available for ND 100 to ND 300
- Available for ND 100 to ND 200
- Available for ND 100 to ND 200
- Available for ND 100 to ND 200
- Available for ND 100 to ND 200

### Recommended improvements

- Solving target conflict between adhesion and offset suitability under buoyancy: Strong adhesion could lead to buoyancy damages.
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1. The designation „Extreme situation“ refers to the geometry of the connection sewage.
2. Assessment of the functionality through optical evaluation of chemically and biologically treated manhole by network operators: 100 Points = 1.0 to 1.5; Optimum = 6.0; computed by means of a non-linear function.
3. Assessment: 100 Points for all tightness tests according to DIBt guideline = 1.0; a test item according DIBt guideline = 1.0; from test item = according DIBt guideline = 1.0.
4. Assessment: Demanded number (volume) test ≤ 1.0; composite thickness = not attained in individual samples, but reaches the mean, the demanded number = 1.0; demanded composite thickness = not attained in individual samples.
5. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.
6. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.
7. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.
8. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.
9. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.
10. Assessment: Demanded modulus (volume) test ≤ 1.0; observed in test item = 4.0; observed in mean = not attained.

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Assessment key of test results: Very good = 1.0 - 1.5; good = 1.6 - 2.5; satisfactory = 2.6 - 3.5; adequate = 3.6 - 4.5; inadequate = 4.6 - 5.5; poor = 5.6 - 6.0.

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The values shown in parentheses are based on mean values.
The initial funding for setting up the institute has been provided by the Ministry for the Environment of the State of North-Rhine Westphalia, Germany’s largest federal state. However, IKT is not owned by the Government. Its owners are two associations which are again non-profit organizations of their own:

a) IKT-Association of Network Operators: Members are more than 120 cities, among them Berlin, Hamburg, Cologne and London (Thames Water). They hold together 66.6% of IKT.

b) IKT-Association of Industry and Service: Members are more than 60 companies. They hold together 33.3% of IKT.

You can find information on projects and services at: www.ikt.de

IKT has been established in 1994 as a spin-off from Bochum University, Germany.

IKT - Institute for Underground Infrastructure is a research, consultancy and testing institute specialized in the field of sewers. It is neutral and independent and operates on a non-profit basis. It is oriented towards practical applications and works on issues surrounding underground pipe construction. Its key focus is centred on sewage systems. IKT provides scientifically backed analysis and advice.