

1. Background

On 6 July 2012, Schlüsselbauer Technology GmbH & Co. KG commissioned the IKT - Institute for Underground Infrastructure for the performance of tests in accordance with the "Registration rules for the selection and use of plastic inner linings for buried waste-water conduits and manholes" issued by the German Institute for Construction Technology (DIBt). The results of the tests for jetting resistance and performance under high-pressure flushing in accordance with DIN 19523 [1] are contained in this report.

The object of testing is the HDPE lining of the "Perfect Pipe Plus" system, which is anchored in the concrete by means of bosses on its rear side.

2. Test for jetting resistance (materials test)

2.1 Test apparatus and performance

The tests for jetting resistance in accordance with Procedure 1 of DIN 19523 [1] were performed at the IKT's outdoor site on 18 October 2012.

A test nozzle with a ceramic insert and an aperture diameter of 2.5 mm moving parallel to the longitudinal axis at a distance of 10 (+0/-2) mm from the pipe base was used for the test (see Figure 1 and Figure 2).

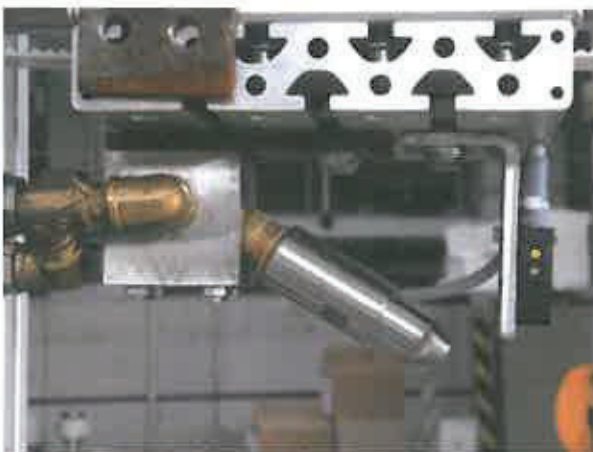


Figure 1: Test nozzle



Figure 2: Test-nozzle insert

For this test, three test cycles were performed on each of three test sections. Each cycle consisted of the forward and backward movement of the flushing head across a length of 1.0 m. The test object was visually inspected after completion of each test cycle. The test sections were arranged at lateral intervals of 10 cm from each other.

The following detailed test parameters are mandatory for performance of testing in accordance with DIN 19523 [1]:

Water and ambient temperature [°C]:	15 ± 10
Flushing-jet energy density D_j [W/mm ²]:	450 ± 15
Distance of nozzle aperture from pipe base [mm]:	$10 +0 -2$
Flushing head angle α [°]:	30 ± 1
Spread angle of flushing jet ω [°]:	≤ 3.3
Nozzle insert d [mm]:	2.5 ± 0.02
Test-section length [cm]:	130
Test velocity (forward and backward) [m/min]:	0.2 ± 0.02

A computer was used to monitor and record the test parameters throughout these tests.



Figure 4: Test apparatus



Figure 3: Performance of the test



Figure 5: High-pressure jet

2.2 Results

Summary of test parameters:

Water temperature [°C]:	16
Ambient temperature [°C]:	18
Length of Test Object l [cm]:	130

Test Section 1:

Distance of nozzle aperture from pipe base [mm]: 8.4 – 9.6

Test Cycle No.	Flow rate Q [l/min]		c _d value [-]		Flushing-jet energy density D _j [W/mm ²]	
	Before	After	Before	After	Before	After
1	35.8	35.8	0.97	0.97	447	446
2	35.9	35.8	0.98	0.97	452	448
3	35.9	35.9	0.97	0.97	453	452

Documentation of damage / Condition of surface

Prior to the test	Smooth, no damage
After Test Cycle 1	Smooth, no damage
After Test Cycle 2	Smooth, no damage
After Test Cycle 3	Smooth, no damage

Test Section 2:

Distance of nozzle aperture from pipe base [mm]: 8.6 – 9.6

Test Cycle No.	Flow rate Q [l/min]		c _d value [-]		Flushing-jet energy density D _j [W/mm ²]	
	Before	After	Before	After	Before	After
1	35.9	35.8	0.98	0.97	450	446
2	35.8	35.9	0.97	0.97	447	451
3	35.9	35.8	0.98	0.98	452	448

Documentation of damage / Condition of surface

Prior to the test	Smooth, no damage
After Test Cycle 1	Smooth, no damage
After Test Cycle 2	Smooth, no damage
After Test Cycle 3	Smooth, no damage

Test Section 3:

Distance of nozzle aperture from pipe base [mm]:

8.7 – 9.9

Test Cycle No.	Flow rate Q [l/min]		c _d value [-]		Flushing-jet energy density D _j [W/mm ²]	
	Before	After	Before	After	Before	After
1	35.8	35.9	0.97	0.98	449	451
2	35.9	35.7	0.98	0.97	450	445
3	35.9	35.7	0.98	0.97	452	445

Documentation of damage / Condition of surface

Prior to the test	Smooth, no damage
After Test Cycle 1	Smooth, no damage
After Test Cycle 2	Smooth, no damage
After Test Cycle 3	Smooth, no damage

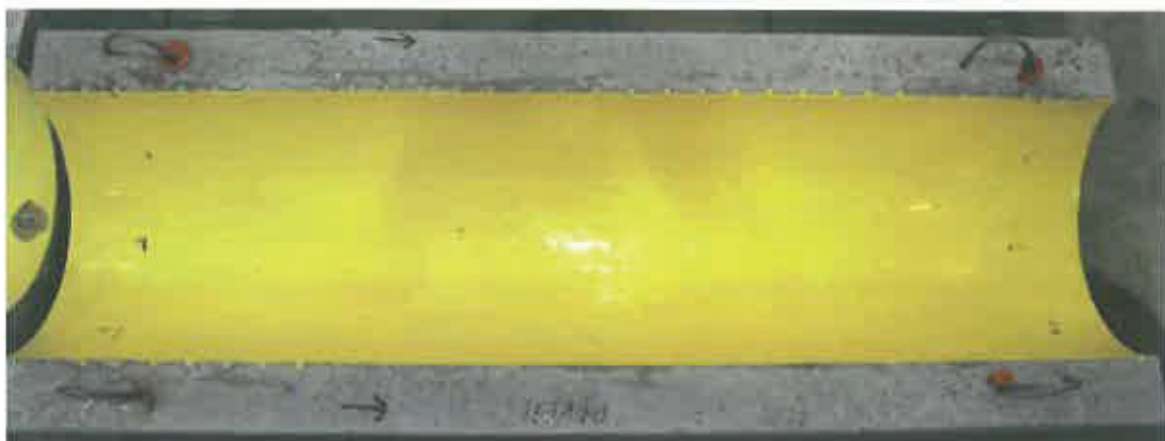


Figure 6: Test Object H2110-1 after the materials test

The HDPE lining of Schlüsselbauer GmbH & Co. KG's "Perfect Pipe Plus" system passed the test for jetting resistance (materials test) in accordance with DIN 19523.

3. Test for performance under high-pressure flushing (practical test)

3.1 Test apparatus and performance

The high-pressure flushing test is based on DIN 19523, Procedure 2 – Practical test, in which the requirements for performance under high-pressure flushing of pipe materials are defined. Schlüsselbauer GmbH & Co. KG supplied a total of seven DN 300 (2 x 1.0 m and 5 x 3.0 m long) concrete pipes lined with the HDPE Perfect Liner to IKT for the test. The pipe sections were connected together by means of bell joints to form a pipe train of a length of 17 m (see Figure 7 to Figure 9).

The test section was visually inspected for damage/abnormalities by an IKT employee prior to the start of the test. No visible damage/abnormalities was/were found.



Figure 8: Test apparatus



Figure 7: Test section

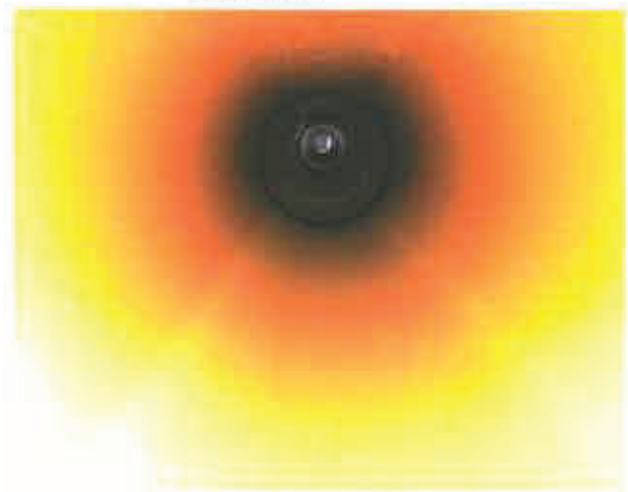


Figure 9: The lining prior to the test

The high-pressure flushing test was performed on 25 October 2012 at an ambient temperature of around 10° C and a water temperature of around 14° C.

A total of sixty cleaning cycles were performed during the test; the nozzle was not allowed to remain stationary in the test zone at any time. Each cycle consisted of the forward and backward movement of the nozzle through the entire pipe train. An eight-jet omnidirectional nozzle (see Figure 10) of a length of (17 ± 0.5) cm, a weight of (4.5 ± 0.1) kg and a nozzle-body diameter of (8 ± 0.5) cm was used for these tests.



Figure 10: Test nozzle

The following test parameters must, in detail, be adhered to during performance of these tests:



Flow rate Q :	280 l/min to 285 l/min
Jet angle α :	$(30 \pm 1)^\circ$
Nozzle-insert diameter d before and after test:	(2.60 ± 0.2) mm
Forward velocity:	(1.0 ± 0.1) m/s
Reverse velocity:	(0.1 ± 0.02) m/s
Number of test cycles:	60
c_d value before and after test:	≥ 0.7
Flushing-jet energy density D_j before and after test:	(330 ± 15) W/mm ²

Pressure was determined at a volumetric flow of between 280 l/min and 285 l/min at a distance of not more than 0.1 m from the nozzle body by means of a pressure sensor both before the start and after the conclusion of each test (see Figure 11, right). Volumetric flow was determined by means of a magnetic-inductive flow-measurement system (MID) (see Figure 11, left). The pressure during the test was monitored by means of the pressure gauge on the vehicle.



Figure 11: MID and pressure sensor for monitoring of the test parameters

Test parameters determined:

	Prior to the test	After test
Pressure at nozzle [bar]	120	100
Volumetric flow [l/min]	282.8	282.0
Flushing-jet energy density D_j [W/mm ²]	341	338
c_d value	0.72	0.78
PC record		

After determination of the test parameters, the test line was exposed to sixty cleaning cycles (see Figure 12 and Figure 13). The HDPE lining of the "Perfect Pipe Plus" system was then visually inspected.



Figure 12: Performance of the test



Figure 13: The nozzle in action

3.2 Result

The HDPE lining of the Schlüsselbauer GmbH & Co. KG "Perfect Pipe Plus" system which was tested exhibited no visible abnormalities (damage) (see Figure 14) after exposure to sixty cleaning cycles at a flushing-jet energy density D_j of between 338 W/mm^2 and 341 W/mm^2 and a volumetric flow of between 282.0 l/min and 282.8 l/min and thus passed the test for performance under high-pressure flushing in accordance with DIN 19523.



Figure 14: The test object after the practical test

4. Conclusion

The HDPE lining of the Schlüsselbauer GmbH & Co. KG "Perfect Pipe Plus" system which was tested passed the tests for jetting resistance (materials test) and performance under high-pressure flushing (practical test) in accordance with DIN 19523.

5. References

- [1] DIN 19523: Anforderungen und Prüfverfahren zur Ermittlung der Hochdruckstrahlbeständigkeit und -spülfestigkeit von Rohrleitungsteilen für Abwasserleitungen und -kanäle (August 2008).