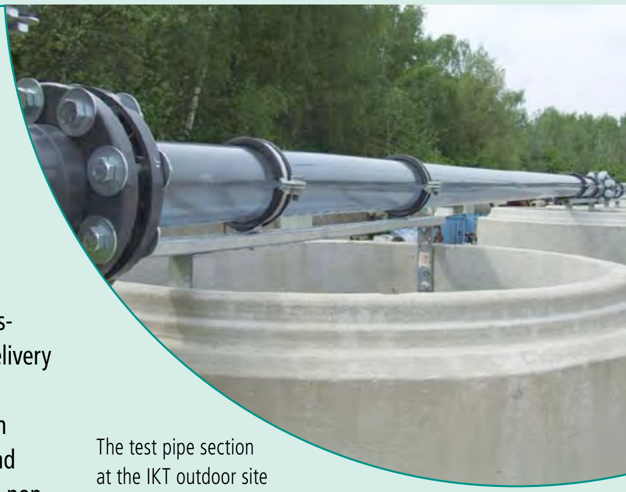
Pipes under pressure



The test pipe section
at the IKT outdoor site

Pressurized waste-water lines (rising mains) can, to a certain extent, be seen as the „neglected" part of the pipeline family. In terms of cleaning and maintenance, they frequently lose out. Many system operators start to feel uncertain where the necessary time for cleaning, and the selection of a suitable method, are concerned. The IKT decided to improve this situation: together with sixteen system operators, the institute examined the potentials and available techniques for the cleaning of pressurized waster-water lines.

The results of the recently completed „Pressurized waste-water lines - Potentials and methods for their cleaning" research project [1] are now available.

The special features of pressurized conduits

The need for the construction of pressurized lines (rising mains) occurs, in particular, in areas of low population density or of inadequate gradient potentials. Around 90 percent of system operators in the German state of North Rhine-Westphalia (NRW) operate pressurized lines (rising mains). Such lines account only for some four percent of the total length of the public waste-water system in NRW (3491 km of pressurized lines), however. Information supplied by operators indicates that they posses only little experience with the cleaning of such conduits.

Cleaning activities in pressurized lines (rising mains) are complicated by the absence of maintenance/inspection openings, gradient changes, high/low points and bends in such conduits, and by their predominantly complete filling. Since many system operators are uncertain of just when cleaning of such lines is necessary, and what methods they can use, cleaning and maintenance of these installations is generally restricted to the pumping stations and venting valves.

It is thus possible for problems and faults, such as the following, to occur during operation of pressurized lines (rising mains):

- Depositions (of grease, for example), which can cause loss of open pipe cross-section, coupled with reduced pump delivery rates and rising energy costs;
- Grease-blockage of venting valves, with resultant defective valve-functioning and
- Blockages which can result in complete non-functioning of the conduit.

Concealed blockage [2]

Undesirable evolution of hydrogen sulfide can produce a problem that will quite quickly draw the attention of the public. This gas is generated as a result of stagnation of the waste-water in case of prolonged residence times in the pipe. Even at low concentrations, emission of hydrogen sulfide gas into the atmosphere in the surrounding area can cause an unpleasant smell of bad eggs. Touchy citizens will then quickly reach for the telephone in order to complain to the system operator. Many people associate unpleasant odours from the drain system with inadequate cleaning of the conduits. The question was, however, the extent to which poor cleaning really is the reason for the generation of hydrogen sulfide.

Many odour-generating processes take place
in the sewer slime

Procedure

The IKT researchers set themselves the target of cataloguing, with the greatest possible practical orientation, the potentials for and limitations on use of the various methods, and assessing their cleaning performance. Reference data for the costs involved was also to be obtained and, finally, the advantages and disadvantages of the diverse methods derived. The project therefore focused on test deployments of various techniques, which were observed and evaluated in cooperation with sixteen system operators.

It was possible to test selected cleaning procedures at a number of different locations:

- Pressurized lines operated by the participating operators
- The test pipe-section at the IKT site and
- The test pipe-section at the Porta Westfalica (Germany) treatment plant.

The practical tests performed on the operators' systems primarily enabled the IKT researchers to obtain information on the handling of the various methods and on the necessary technical preconditions.

The IKT test section specially developed for this project was used in order to simulate various deposition situations and to test the methods in the context of cleaning trials under identical boundary conditions. It was thus possible to derive comparative information concerning, for example, cleaning performance and physical transport characteristics. The IKT researchers were able here to simulate, and investigate in more detail, problems which had not been answered during the practical deployments.

The test section at the treatment plant was colonized with sewer slime to permit supplementary cleaning tests. This test section conveys waste-water from the treatment plant's inflow, unlike the IKT test section, which is operated with fresh water.

Pressurized lines

Methods examined

The participating system operators decided to include the five following cleaning methods in the project program:

- *Impuls-Spül-Verfahren* (pulse-flushing method)
- Pigging
- High-pressure cleaning using a drain flushing nozzle
- The „Lipolyt 2000" biological cleaning method and
- Generation of elevated flow velocities by means of an ejector and a hydrant

The main focus was on testing of the *Impuls-Spül-Verfahren* (pulse-flushing) and the pigging method, procedures specially developed for pressurized lines (rising mains), alongside the high-pressure flushing nozzle widely used in gravity drains. All the methods were assessed both in the system operators' pressurized lines and in test pipe sections. A hydrant and an ejector were also used for flushing tests in the IKT test section.

The definitive reason for also testing a biological method in existing pressurized lines (rising mains) can be found in its field of application: in addition to reducing, or even eliminating, organic depositions, it is also said to suppress the formation of hydrogen sulfide, and thus help in combating unpleasant odours.

Feeding of compressed air during a pulse-flushing operation

Pulse-flushing: In the patented *Impuls-Spül-Verfahren* (pulse-flushing method), large volumes of compressed air are injected in pulses into the conduit. It was noted in the IKT test pipe section that turbulent mixtures of air and water of a length of several meters occurred, filling the entire pipe cross-section and passing at high flow velocities through the pipe.

Pigging: In the pigging method, a cleaning-pig is inserted into the pressurized line (rising main) and propelled through it by a propellant fluid (generally water). This dislodges depositions from the pipe wall and conveys them out of the pipe. A number of cleaning cycles, using different types of pig, are performed, depending on the fouling situation. The pigs differ in terms of their materials, diameter, hardness and surface characteristics.

Insertion of a foam pig

High-pressure cleaning: It is necessary, if a high-pressure flushing nozzle is to be used, to take the pressurized line (rising main) out of operation and to open a manhole. The flushing hose is then inserted into the line via this opening. Standard drain-flushing-vehicle hoses generally vary in length between 80 and 120 meters. Actual operating range („reach") is usually significantly less than this, however, due to frictional resistance caused by flushing sockets, the pipe wall, and any depositions present. The limited reach of such flushing hoses means that maintenance and inspection manholes are necessary at short, regular intervals.

High-pressure flushing nozzle

The „Lipolyt 2000" biological method: According to information supplied by the manufacturer, this product contains microorganisms, enzymes and a carrier material. The microorganisms, on the one hand, are intended to break down and dislodge organic depositions. Their other function, on the other hand, is to expel sulfide-producers and thus prevent the evolution of hydrogen sulfide. All sulfide-production points, i.e., all pump shafts and siphons, are „inoculated" with this product.

Input of „Lipolyt 2000" into a pump shaft

Flushing using ejector and hydrant: In individual tests at the IKT test section, a hydrant and an ejector were used to generate elevated flow velocities. In the ejector method, water in a tank (or the outflow in a pipeline) is accelerated by generating a partial vacuum. The water to be conveyed is fed into the ejector via the water-intake connection. The high-pressure hose of a flusher vehicle, via which the pressurized water is conveyed in the nozzle element inside the ejector, is connected to the propellant-water connection point. The propellant water accelerated via the nozzle elements produces a partial vacuum and entrains the water fed via the suction connection.

Ejector

The IKT test section

The IKT test pipe section consists of an around 30 m long, virtually horizontal „standard zone" and an around 30 m long „extreme zone". The extreme zone features high-points and low-points, and bends of between 45° and 90° (in the form of PVC elbows).

Various depositions were applied in the standard zone, in order to permit observation of the dislodging and mobilization of such depositions. The onward conveyance of dislodged depositions was recorded in the extreme zone.

The simulated deposition situations were intended, on the one hand, to cover a broad range of possible fouling situations and, on the other hand, to provide extreme conditions in order to permit approximate assessment of the performance limits of the various methods. Adhering depositions consisting of grease and mixtures of grease and sand, highly solidified depositions in the form of liquid bedding material and floor-topping, and non-cohesive, unsolidified depositions consisting of gravelly sand, progressing to gravel and to larger individual stones, were thus positioned in the test section. In addition, blockage by sandy, gravelly fractions, combined with fibrous, binding elements, was also simulated.

Results

Impuls-Spül-Verfahren (Pulse-flushing method)

The pulse-flushing technique exhibited the highest conveying performance in the test section, but its dislodging force was lower than that of the pigging method and the high-pressure flushing nozzle. It was able, for example, to convey depositions such as sand and gravel, and also individual larger stones, but not to completely remove tightly adhering fouling, such as grease.

The conveying rates achieved by the *Impuls-Spül-Verfahren* (pulse-flushing method) and recorded in the test section could, possibly, also decrease with increasing cleaning length, other pipe materials and other conduit configurations. The basic precondition for the effectiveness of pulse flushing is therefore the setting-up of an adequate number of flushing stations, and that the pulses can be generated at sufficiently high pressures and volumes.

One advantage of the *Impuls-Spül-Verfahren* (pulse-flushing method) is that fact that it is generally not necessary to shut down the pumping station.

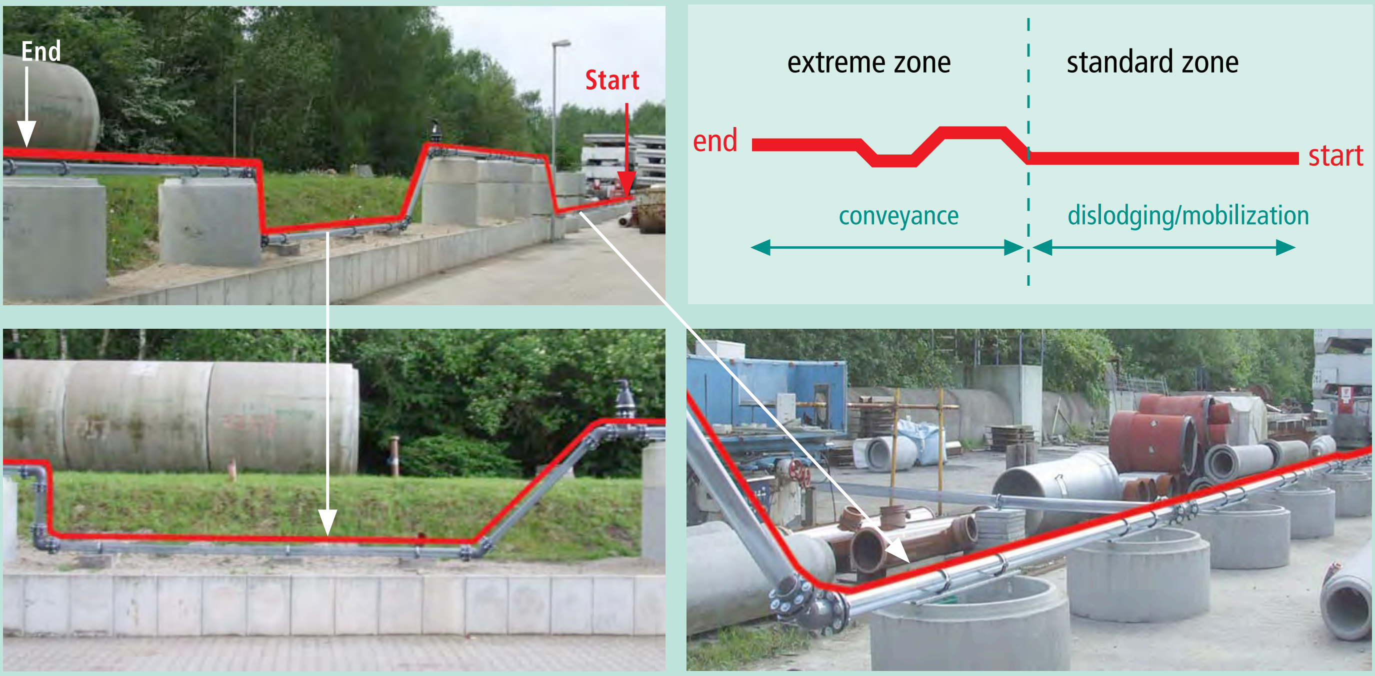
Pigging

Pigging, alongside the high-pressure flushing nozzle, exhibited the highest dislodging force. It was able, for example, to completely remove even powerfully adhering depositions of grease in the test section. The precondition for best-possible cleaning performance is, however, the use of a pig tailored to the particular deposition conditions. Conveying performance was significantly better than that of the high-pressure flushing nozzle, with the result that pigs were also able to remove heavy sand depositions easily. Conveying difficulties can occur under extreme conditions, featuring tight bends combined with heavy or voluminous depositions.

One advantage of pigging is found in its high dislodging force and in the fact that it is, in many cases, possible to clean several kilometers of line length in a single operation.

High-pressure flushing nozzle

The high-pressure flushing nozzle also exhibited good dislodging power in the test section, but the nozzle's conveying performance was severely restricted, as a result of the flushing water building up in the conduit. In addition, both the trials performed in the test section and practical tests demonstrated that cleaning using high-pressure flushing nozzles involves a high level of work input and that there are, in addition, clear limits on utilization. The reach of the flushing



The IKT test section: transparent Plexiglas pipes, DN 100, length approx. 60 m

Pressurized lines

Deposition situation		Cleaning performance			
		pulse-flushing	Pigging	HP nozzle	Ejector/hydrant
non-cohesive, non-solidified	Gravelly sand (0/8)	+ [2]	+ [2]	+ [2]	+ [2]
	Gravel (20/40)	+ [2]	~ [2]	– [2]	– [2]
	Stones	+ [1|2]	~ [2]	No test	No test
adhesive	Sewer slime	o [1|2|3]	+ [3]	+ [1]	No test
	Grease/sand	o [2]	+ [2]	o [2]	– [2]
	Grease	– [1|2]	+ [2]	+ [2]	– [2]
solidified	Liquid bedding material*	+ [2]	+ [2]	No test	No test
	Floor-topping*	+ [2]	~ [2]	– [2]	– [2]
solidified, sealing	Blockage	– [2]	– [2]	+ [2]	– [2]

* Not classifiable as an encrustation, due to low surface roughness

\+ Dislodging and conveyance possible, (practically) complete removal

o Dislodging and conveyance largely possible

– Dislodging not possible or possible to only a limited extent, and/or conveyance not possible or possible only to a limited extent

~ Dislodging possible, conveyance problem at angled elements

1 Results from practical test

2 Results from IKT test section, PVC DN 100, L=60 m

3 Results from Porta Westfalica (Germany) test section, HDPE DN 100, L=100 m

Cleaning performance of various methods from cleaning tests performed in-situ, at the IKT and in Porta Westfalica

hose is, for example, limited, with the consequence that maintenance and inspection shafts are necessary at short intervals.

The fact that even the simulated blockages were eliminated should be mentioned as a basic advantage of the high-pressure flushing nozzle over pulse-flushing and pigging. In practice, however, the precondition for this is that the nozzle can actually be fed into the pipeline as far as the location of the blockage.

The „Lipolyt 2000“ biological method

It was not possible, in the context of four practical tests, to clearly verify the effectiveness of the „Lipolyt 2000“ biological product. In three tests, the effects stated by the supplier, viz.:

- Breakdown of depositions and surface slime in the shaft
- Reduction of sewer slime in the line and
- Avoidance of hydrogen sulfide formation

did not occur with any particular clarity.

In the fourth test, still continuing hydrogen sulfide measurements should also be augmented at a warmer period of the year.

Information has, however, been received from system operators, stating that the use of this product has reduced depositions at pumping stations and odour problems caused by hydrogen sulfide.

Numerous biological methods for combating of odours and/or for breakdown of organic depositions are available on the market. The results obtained with the Lipolyt 2000 product tested cannot be assumed without modification for other products and methods, due to their differing compositions.

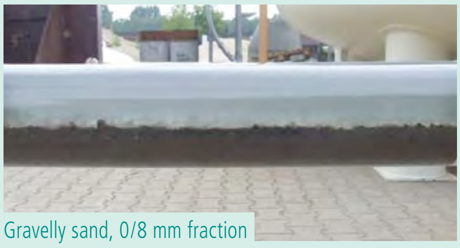
Elevation of flow velocities using ejector and hydrant

The connection of an ejector and a hydrant to the test section succeeded only to a limited extent in generating elevated flow velocities. Non-cohesive depositions of sand were flushed out without difficulty, whereas gravelly and adhering depositions consisting of grease or mixtures of sand and grease remained unaffected. The potential applications are restricted to systems with only slight height differences in the pressurized lines (rising mains) and small conduit diameters, due to the limited delivery heads and delivery rates of ejectors and hydrants.

Evaluation

The basis for the evaluation is provided, in particular, by the experience gained from tests in the IKT test section. It should be noted when studying the cleaning performances shown that the simulated deposition situations in the test section in some cases involved extreme conditions. As the experience of system operators indicates, sewer slime and grease depositions can be regarded as more frequently occurring

Grease



Gravelly sand, 0/8 mm fraction

Blockage[1]

Examples of depositions from the IKT test section

deposition situations, and blockages do occur in some cases, whereas severe depositions of sand or gravel are rarer.

The pulse-flushing, pigging, high-pressure flushing nozzle, and ejector-flushing methods can be directly compared in the assessment. These are techniques which are used, and were tested in the IKT test section, in case of the existence of depositions of mineral and/or organic origin. The biological process examined, on the other hand, should be assessed separately, due to its applications, which are primarily found in the avoidance of organic fouling and of elimination of hydrogen sulfide evolution.

It is possible to state by way of conclusion from the results of these tests that both pulse-flushing and pigging are suitable methods for cleaning of pressurized waste-water lines (rising mains), but that each method has its own particular advantages and disadvantages.

Flushing operations using high-pressure flushing nozzles manifested an extremely good dislodging performance, but these systems are subject to serious limitations in terms of reach. Ejectors and hydrants achieved acceptable cleaning results only in removal of easily detachable fouling.

It is possible to eliminate or reduce the problem of odours caused by evolution of hydrogen sulfide only for a short time, at best, using the mechanical cleaning procedures. Excessively long waste-water residence times in the pressurized line (rising main) should be regarded more as the cause of production of odours from hydrogen sulfide than the frequency of or lack of cleaning.

Results available on the Internet

This article provides only a summary of the results of the „Pressurized waste-water lines - Potentials and methods for their cleaning" project. Both the abbreviated and the complete version are available, with more details and all results, for download from the Internet at www.ikt.de

Source: IKT eNewsletter, March 2007

[1] mixture consisting of gravelly sand, dead leaves, fibrous materials [bast, hemp, toilet paper], bentonite particles and water

Bibliography

[1] Bosseler, B.; Harting, K.: Abwasserdruckleitungen – Möglichkeiten und Verfahren zur Reinigung („Pressurized waste-water lines - Potentials and methods for their cleaning"); IKT – Institute for Underground Infrastructure, on behalf of the NRW Ministry of the Environment (MUNLV), 2006

[2] Illustration courtesy of the Municipality of Billerbeck, 2006

neutral
independent
non-profit institute

IKT - Institute for Underground Infrastructure

ABOUT IKT

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.

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

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 about 100 cities, among them Berlin, Hamburg, Cologne and London (Thames Water). They hold together 66.6% of IKT.

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

You can find information on projects and services at:
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Published: April 2008
Circulation: 5.000 copies
Protective charge: 19,95 €