

## Waste-water culverts: The forgotten feature

Wherever features such as streams, rivers and tunnels prevent the natural flow of waste-water, culverts perform the task of conducting the waste-water under the obstruction to be traversed. Completely filled culverts confront system operators with a number of challenges when inspection and cleaning of these special structures become necessary. For the „Use of Ejector-Technology for Inspection and Cleaning of Culverts“ research project [1], the IKT focused its attention on these problems.

### Inspection not the main problem

Prior to the start of the project, the IKT performed a survey of 208 system operators from the German state of North Rhine-Westphalia to obtain basic information on experience with waste-water culverts [2]. This survey indicated that water control, and not inspection, is the central problem:

- The maximum available inspection periods when culvert feeders are flanged off, with back build-up of water, is too short for TV-based inspection.
- Overpassage of the waste-water causes great technical, economic and organizational input and is therefore not a method used by the operators surveyed.
- Through-passage of the waste-water using hoses or pipes is a method conceived for use in gravity lines and is also not used by the system operators surveyed in the case of culverts.

It is therefore necessary to find new technical solutions, since both overpassage and through-passage of waste-water for water control are either not practicable or have, at least, not been tested, using existing technology. One option, as an initial step, is the use of tools which have already proven their capabilities in similar applications. One such aid is the ejector nozzle. Such nozzles can be used to clean and drain the culvert, and to keep it free of waste-water for inspection. For

the „Waste-water culverts“ research project [1], the IKT researchers analyzed the practical use of ejector technology both in laboratory tests and in the context of system operators' inspection operations.

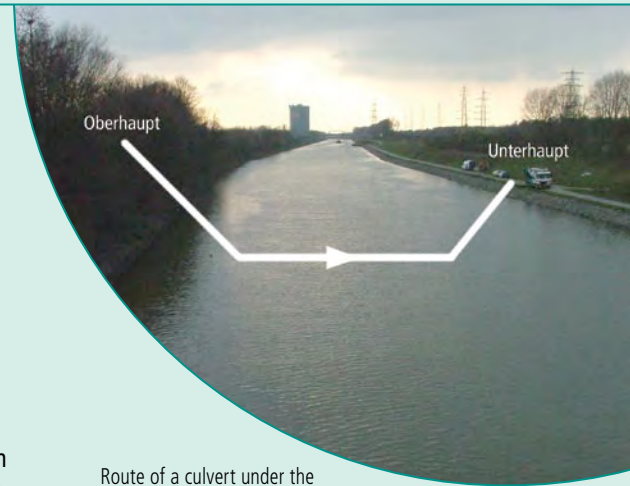


Multi-jet ejector: high-pressure-water hose connection (No. 1, red arrow), intake aperture (No. 2, blue arrow), outlet aperture (No. 3, green arrow; propellant water [ $Q_{\text{propel}}$ ] and conveyed fluid [ $Q_{\text{convey}}$ ] exit at this point)

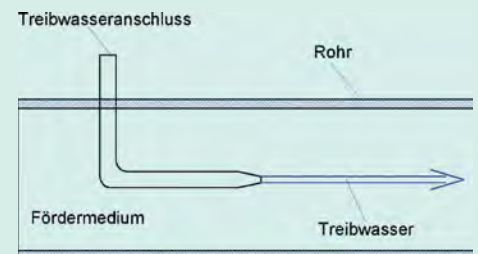
### Ejectors: the technology

A common application for ejector systems can be found in eductor-jet pumps, in which the liquid to be conveyed is accelerated by an added liquid, and is thus pumped (liquid-jet-liquid ejectors). Ejectors can, however, also be used for conveyance of gases and solids. The ejectors used in management and operation of drains and sewer take the form of liquid-jet-liquid ejectors. The pressurized water from the flusher vehicle is fed to the ejector via a propellant connection. The water pressure is converted to kinetic energy in the ejector nozzle, and the propellant water is thus accelerated. The directional flow of propellant water thus generated entrains the liquid of the added conveyed fluid (waste-water, for example) as a result of the viscosity of the liquid. Along the remainder of the flow path, the propellant water and the conveyed fluid mix, until complete pulse equalization is reached.

The advantage of the use of ejector technology in drains and sewers can be found in the fact that an extremely high pump capacity generated using existing technology can be exploited, thanks to the flusher vehicles already available



Route of a culvert under the Rhine-Herne Canal in Oberhausen (length 90 m; diameter 1.0 m)



The operating principle of a liquid-jet-liquid ejector, ejector

for conduit cleaning. Ejector systems also offer benefits in terms of working safety, since there is no danger of explosion, and, in addition, the equipment is already familiar from daily conduit-cleaning operations and can be used without any need for special instruction or training of the workforce.

### Ejectors in practice

In drain and sewer management, ejectors can be used both as cleaning tools and as pumps. Only a few system operators possess experience with ejector technology. In the framework of this project, this experience was both surveyed in the context of in-person talks and registered and documented by means of visits to selected operators. In addition, the use of ejector systems for water control at culverts was also observed at the worksites of three system operators in Ratingen, Arnsberg and Oberhausen, in order to include examples of practical application.

In the German state of Lower Saxony, system operators from Göttingen and Hanover possess good experience with the use of ejectors. In 1981, Stadtentwässerung Göttingen (Göttingen Municipal Drainage Authority) for the first time

used an ejector for pumping off of sludge. This organization nowadays uses ejectors for cleaning of conduits of DN 250 and above. This cleaning procedure is also known as „soft cleaning“. In their „pump“ function, ejectors are also used for filling of high-pressure vehicles, for the location of flooded road routes and also for drainage of culverts. In Hanover, ejectors are in successful use for cleaning of drain and sewer conduits of DN 800 and above. The responsible engineers here emphasize these systems' high conveying performance in partially filled conduits.



Use of a filter ejector for filling of a high-pressure cleaning vehicle with water from the River Leine, 1982

A number of system operators from North Rhine-Westphalia reported unsatisfactory experience with the use of ejectors for conduit cleaning, stating as their reasons poor tractive effort with only inadequate cleaning performance. In some cases, the ejector tube also became blocked by large stones. Bar-cages positioned in front of the ejector intake can provide a remedy for this. The use of a standard ejector as a pump for discharge of digester tanks is a special application mentioned. Using an ejector, the sludge from a digester can be completely discharged within two working days.

The three pilot projects in Ratingen, Arnsberg and Oberhausen made it possible to confirm the positive experience gained in other federal states of Germany and to apply it to culverts in North Rhine-Westphalia. Provided the ejector technology was correctly used, it was possible to clean, drain and inspect the culverts within a single working day.

Ejectors are particularly suitable for cleaning of culverts of diameters greater than DN 400. The water from the completely filled culvert is used by the ejectors in the cleaning process and depositions are flushed out of the culvert.



Ejector with connection points on both sides

In none of these special structures was the precise location of the lowest point in the culvert known. It was necessary, in order to achieve complete culvert drainage, to repeatedly relocate an ejector iteratively until the lowest point in the culvert was found. Contrary to the information supplied by the system operators questioned in [2], according to which the maximum possible inspection periods available for TV inspection are too short when the method of flanging off of



Left: An ejector in use  
Right: Insertion of the inspection camera

culvert feeders with build-up of water is used, it was possible in all these three pilot projects to secure the drain for inspection using this procedure. The use of overpassage of the waste-water, which involves a high level of technical, financial and organizational input and for these reasons is not practiced by the operators surveyed, was also not necessary here. Thanks to the use of ejector technology, the time-window available for draining and camera-based inspection of the culvert was adequate in all three projects.

## Conclusion

It is possible to ascertain by way of conclusion that the use of ejectors permits support of the overall culvert-inspection process as follows:

- Cleaning of completely filled culverts using ejectors;
- Water control, in the form of flanging off of the culvert head, for example, possibly combined with the use of ejectors for pumping off and overpassage of the waste-water;
- Use of ejectors positioned at the lowest point in the culvert for drainage of the culvert pipe and
- Culvert inspection by means, for example, of camera-based surveying.

Ejectors can be used as both cleaning nozzles and as pumps in such projects. The ejector can be regarded as a robust and easy-to-handle dual-function (cleaning and pumping) tool which is powered by standard high-pressure cleaning vehicles and can be combined with the components already in use in drain and sewer operation. Ejectors are also used for other applications in which it is necessary to move water, waste-water, sludge and/or coarse depositions.

## Results in the Internet

This article provides only a summary of the research results. The complete version of the „Use of ejector technology in culvert cleaning and inspection“ research report is available for download the Internet: [www.ikt.de](http://www.ikt.de)

## References

- [1] Bosseler B., Bennerscheidt C.: Use of ejector technology in culvert cleaning and inspection. IKT- Institute for Underground Infrastructure concluding report, on behalf of the NRW Ministry of the Environment (MUNLV), 2004. Available for download at [www.ikt.de](http://www.ikt.de)
- [2] Bosseler, B.; Gronau U.: „Inspection and cleaning of culverts“ experience report, IKT – Institute for Underground Infrastructure, 2002

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**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.

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