The comprex® impulse cleaning process for cleaning municipal pressure pipework

Authors:
Dr. Norbert Klein, Hammann GmbH
Sebastian Immel, Hammann Engineering GmbH

From air-water flushing to Impulse cleaning

Hammann has been cleaning pressure pipelines using the impulse flushing method since 1997. It all started with two vehicles in the municipal sector with pipe network cleaning. The focus was on pipelines with nominal diameters of DN 80 to DN 200. The effectiveness of the process quickly became known. More and more applications were added, such as the cleaning of transport pipelines, raw water pipelines and borehole well pipelines. Larger nominal diameters required more powerful cleaning units. The development from the original pipe network flushing with air and water to efficient comprex impulse cleaning began. Another milestone was the entry into the cleaning of drinking water installations in buildings. The reason for this was the increasing problem of legionella in hot water systems and pseudomonas in cold water pipelines. This ultimately led to involvement in research projects.

However, an increasing number of enquiries also came from the industrial sector. In addition to cleaning pipework for a wide variety of applications, it became apparent that heat exchangers and other equipment could also be cleaned effectively. This area has grown rapidly in recent years. New requirements need suitable solutions. Today, for example, small comprex modules are used by manufacturing facilities in production lines. A new addition is industrial plant engineering for special comprex units in various industrial sectors. Figure 1 shows the milestones in the company's history [1].

1997	Founded as Hammann Wasser Kommunal
1998	Municipal pipe network cleaning using the impulse cleaning method
2005	Cleaning of drinking water installations in buildings
2008	Cleaning of industrial systems
2009	Renamed HAMMANN GmbH, introduction of comprex® brand
2010	Full-service provider for mechanical cleaning
2014	EP patent “Modulex”
2017	EP patent “Optimex”
2017	Establishment of Hammann-Sinner GmbH in Schweinfurt, Germany
2018	Establishment of Hammann Engineering GmbH for sale of mobile and stationary comprex® equipment
2019	Establishment of sycotech GmbH for software development
2022	Establishment of comprex Wilseko® S.R.O. in Kosice, Slovakia
2023	Establishment of comprex® North America LLC in Cincinnati, Ohio, USA
2024	EP patent “comprex® Process”
2025	New headquarter in Landau in der Pfalz, Germany Exclusivity agreement with IES for UK & Ireland

Figure 1: Selected milestones in the company's history [1]

Hammann’s sphere of activity is expanding constantly. comprex units are now in use throughout Europe, for example in Switzerland (Figure 2) [2] and the Baltic Region. The following article deals primarily with comprex impulse cleaning in the municipal sector, in particular pipe networks and pressurized pipelines for drinking water supply and wastewater disposal.

Figure 2: comprex unit on Lake Lucerne, Switzerland

The comprex process for cleaning drinking water pipelines
The comprex process has a wide range of applications. Although the procedure may vary depending on the application, the principle is always the same.

Firstly, it is necessary to define cleaning sections with inlet and outlet points. Figure 3 illustrates the principle of comprex impulse cleaning using the example of a pipeline for drinking water distribution. Here, the cleaning sections are defined by shut-off valves, mainly by gate valves. Inlet and outlet points are whydrants. In the case of underground hydrants - as shown in Figure 3 - standpipes are required. The comprex unit is located at the injection point and a discharge box or other device for releasing the compressed air is located at the discharge point. These are connected to the available hydrants via suitable hoses. For cleaning, the valves are closed and the hydrants at the inlet and outlet points are opened.

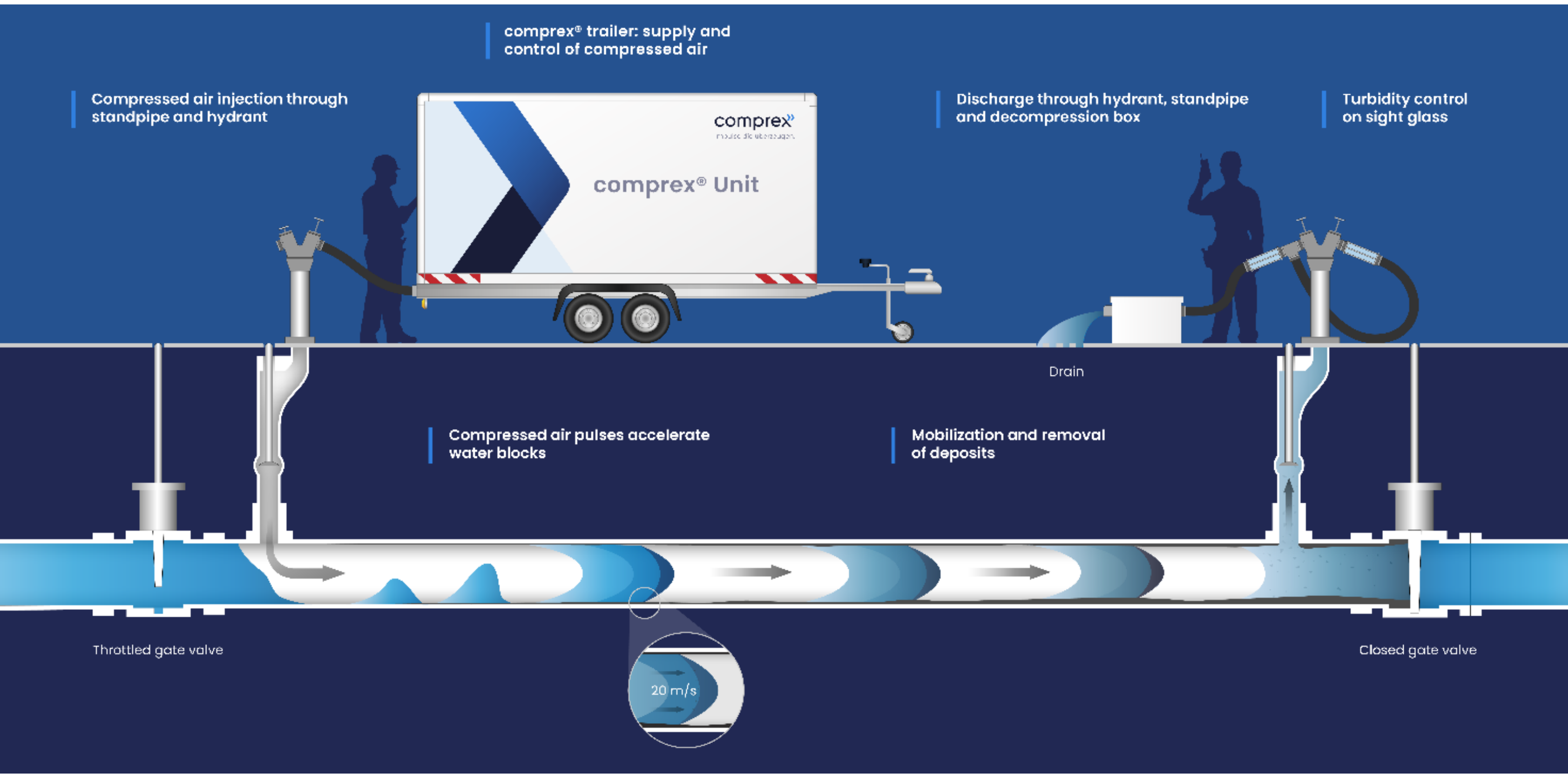

Figure 3: Principle of comprex impulse cleaning on a section of a drinking water pipeline

Cleaning takes place in several phases. Firstly, the cleaning section is set to a partially filled state by throttling the inlet valve and carefully pressurizing it with compressed air from the comprex unit (Figure 4). During the entire process, the pressure always remains below the operating pressure of the pipework to be cleaned.

The actual cleaning process then begins. Compressed air is injected into the partially filled pipeline section by the control software of the comprex unit. There, the air can expand almost instantaneously, and thus forms impulse-like cleaning-effective plugs of water and air blocks. The effectiveness of the cleaning initially depends on the speed at which these comprex plugs move through the pipework. In the comprex process, the speeds are over 15 m/s, often even well over 20 m/s. It is not entirely accurate to speak of velocity or even flow velocity because acceleration effects also have a decisive influence on the effectiveness of the cleaning process. To form plugs, the surface of the present water in the pipeline invert is brought up to speed in fractions of a second. Acceleration and speed together result in the shear velocity and associated shear stress required to remove deposits. This is many orders of magnitude higher with the comprex process than with simple water flushing.

Figure 4: comprex unit at the feed point

When cleaning drinking water pipelines, no drinking water is available from the sections being cleaned during operations. Neighbouring residents are informed of this in advance. While conventional water flushing requires a lot of water and has the risk of pressure drop and turbidity in the neighbouring pipe network, the water requirement for comprex impulse cleaning is much lower (Figure 5). This means that residents in the neighbouring distribution network maintain existing clean drinking water levels. Neither turbidity due to swirling deposits nor pressure losses impair the supply. Cleaning is always carried out systematically within a clear isolated section. The water for cleaning operations comes from a clean or purified supply pipeline source to avoid contamination.

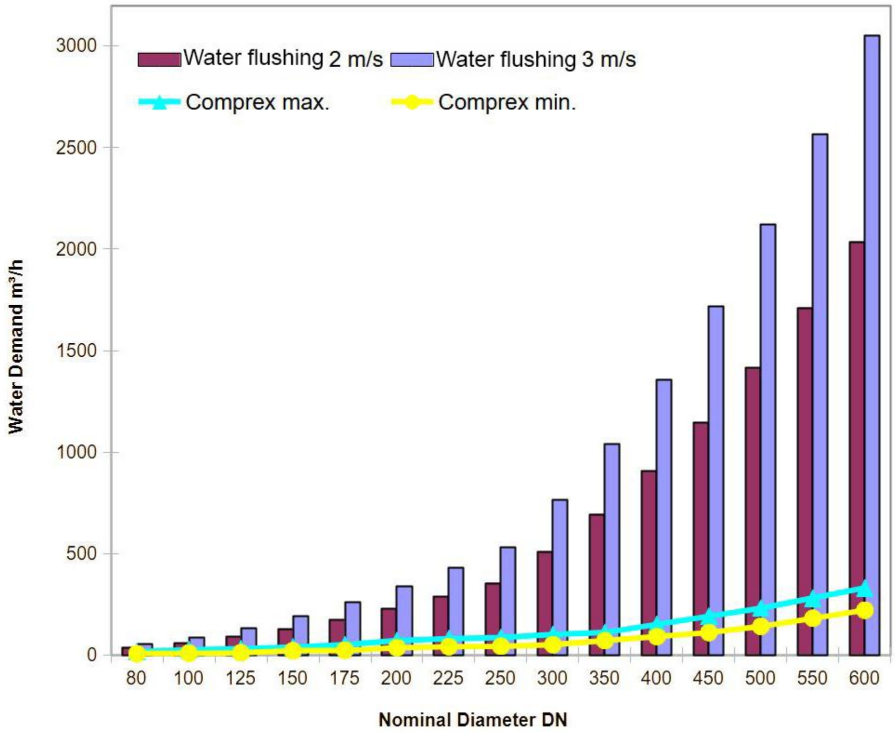

Figure 5: Water requirement for comprex impulse cleaning compared to water flushing depending on nominal size

Low water consumption also means low flushing water consumption. This is particularly important for large-diameter pipework where it is not permitted to directly discharge particle-loaded flushing water. As the comprex process is a mechanical process, simple sedimentation is sufficient to treat the flushing water. The settled particles can be disposed of without great effort.

Preliminary planning is always required before cleaning measures, especially for complex pipe networks. This allows efficient cleaning procedures and saves residents unnecessary time without drinking water. Pre-planning also serves the purpose of cleaning all areas between hydrants and gate valves, thereby avoiding dead legs. Furthermore, pipeline sections that have already been cleaned using the comprex process can be vented before being recommissioned.

The comprex process for cleaning pressurized wastewater pipelines

In contrast to drinking water pipelines, there are no hydrants in pressurized wastewater pipelines. Here, connections to air valves or drains are used to feed in the compressed air (Figure 6). The discharge point is normally located at the end of the wastewater pressure pipeline. It is either the outlet into the sewage treatment plant or into a sewer, usually in a manhole.

Figure 6: Inlet points for compressed air in wastewater pressure lines at air valve or drain points

It has proven to be a good idea to inspect and clean or, if necessary, replace the air release valves before comprex impulse cleaning. Adequate couplings are used as compressed air connections, either directly or via adapters. There is always a system separator between the comprex unit and the compressed air connection.

In contrast to the drinking water network, cleaning begins at the feed point furthest away from the pumping station using the water from the pumping station. On the one hand, the water column between the pumping station and the feed-in point is not compressible, so that the comprex pulses can optimally clean the last section to the discharge point. This procedure provides a clean pipeline with an optimum cross-section available for the sequential cleaning the other sections, working backwards towards the source pump.

Culverts or siphons [3] [4] are particularly critical areas of a wastewater pressure pipeline. Debris or stones can cause problems here. The images in Figure 7 are from an article published in October 2016 [5]. Coarse particles led to breakthroughs in the inner surface area as a result of abrasion.

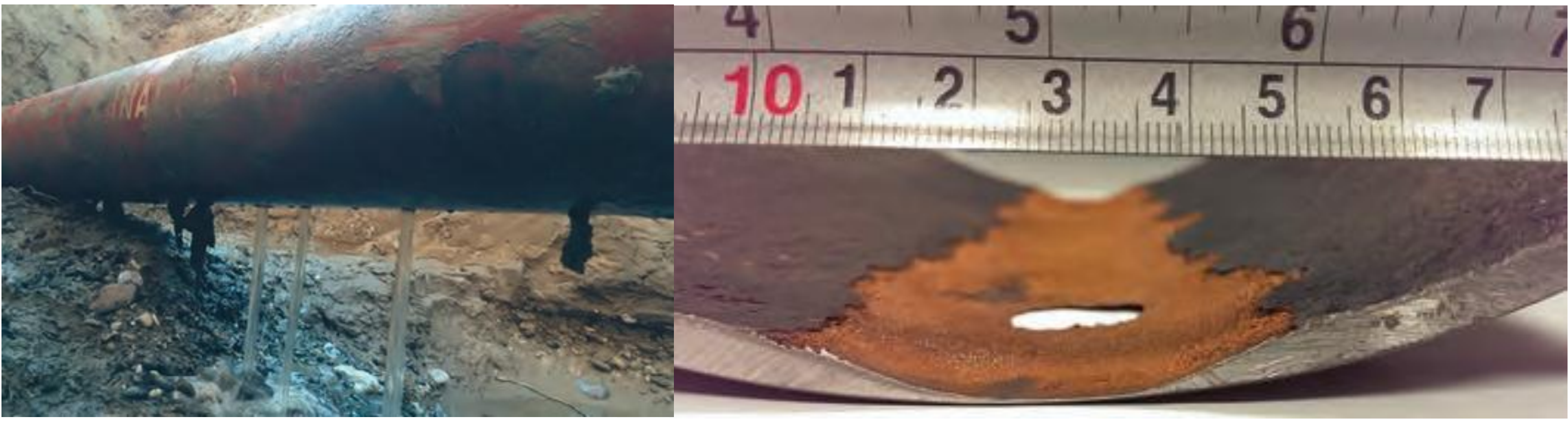

Figure 7: Pipeline breakthroughs due to abrasion of coarse particles in the inner pipe surface [5]

Figure 8 illustrates the comprex impulse cleaning at the culvert. After cleaning the section between injection 3 and the sewage treatment plant, the culvert is cleaned. Here, the comprex unit feeds the compressed air pulses at injection 2 into the water coming from the pumping station. This ensures that coarse particles are reliably removed. Research reports [6] and practical experience with large-diameter pipelines [7] prove the reliability of the comprex process for this task.

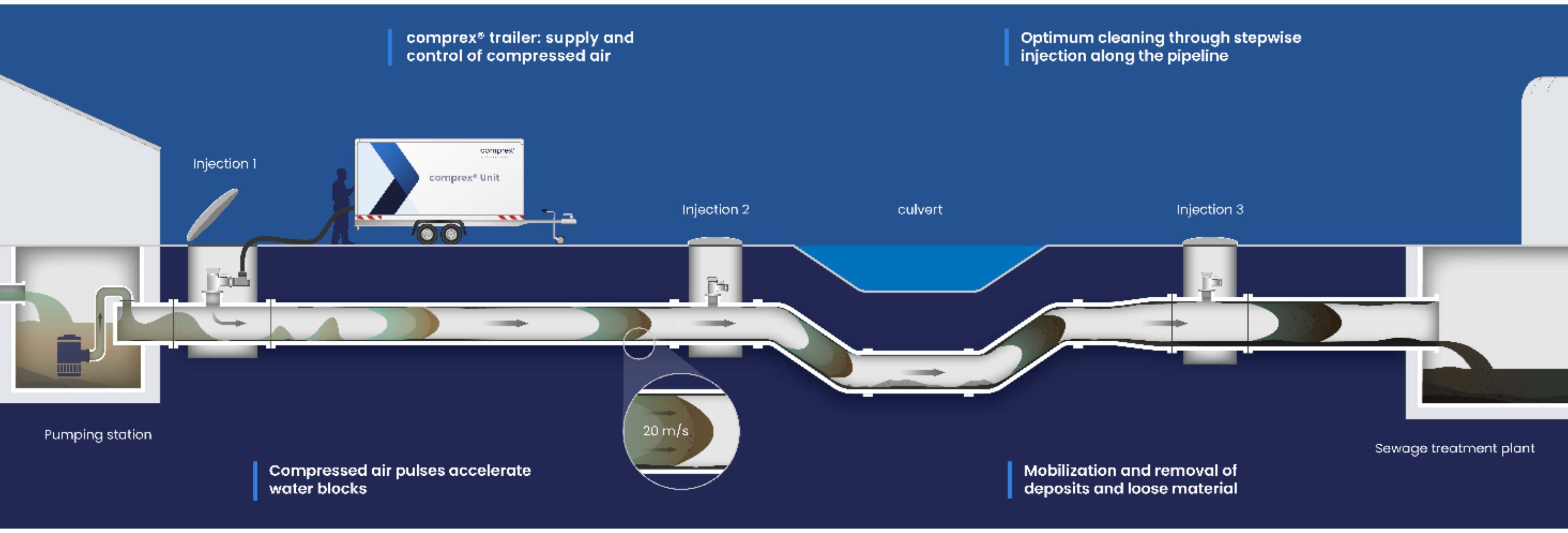

Figure 8: Cleaning a culvert in a pressurised wastewater pipeline using the comprex process

In contrast to the cleaning of drinking water pipelines, the cleaning of pressurised wastewater pipelines has the advantage of being able to be carried out during operation, i.e. "online" [4]. The wastewater accumulated at the pumping station is used together with the comprex pulses to clean the pipework. This means that there is no downtime during cleaning. Compared to pigs, there is also no risk of blockages because the comprex plugs adapt to any geometric shape of the pipework.

Figure 9: Aged grease deposits from wastewater pressure pipeline after comprex impulse cleaning

The comprex plugs with their high velocity and acceleration generate strong shear velocities and shear stresses that act on the deposits. The innovative, patented comprex control system modulates these plugs in such a way that, on the one hand, they achieve high shear stress in the cleaning section to mobilise the deposits, and, on the other hand, they discharge the mobilised particles (Figure 9). The pulse pressure always remains below the operating pressure of the pipework to prevent damage.

Applications of the comprex process

Reasons, task and purpose for a comprex impulse cleaning are different (Table 1). In the case of drinking water pipelines, the hygienic aspect takes priority, and in the case of pressurised wastewater pipelines, the hydraulic aspect. In the case of raw water pipelines as well as pressurised wastewater pipelines, the safety aspect and the possibility of saving pump energy play an increasingly important role.

Table 1: Applications for comprex impulse cleaning depending on the type of pipework

Type of pipework	Reason	Task	Purpose
Newly constructed drinking or raw water pipeline	Commissioning	Remove assembly-related auxiliary materials and impurities	Hygienically perfect condition
Existing drinking water pipeline	Turbidity of the water	Remove deposits and turbidity	Clear drinking water, preparation for inhibitor dosing if necessary
	Animals in the water	Remove debris, vegetation and animals	hygienically perfect condition
Existing drinking or raw water pipeline	Contamination	Remove deposits and fouling	Prerequisite for disinfection
	Reduced flow rate	Remove deposits	Improve hydraulics, Reduce pump energy
Sewage pressure pipeline	Reduced flow rate	Remove deposits	Improve hydraulics, Reduce pump energy

The comprex process is primarily used for existing pipelines. However, it can also be useful for cleaning newly constructed drinking and untreated water pipelines. The following sections explain the relationships in addition to Table 1.

Newly constructed drinking or raw water pipelines

Newly constructed pipework contains assembly aids and impurities caused by the construction process. In the drinking water sector, newly constructed pipework sections for raw or drinking water must be cleaned before commissioning to ensure that they are in perfect hygienic condition [8]. Disinfection is then often no longer necessary, which can be particularly advantageous for pipelines with large nominal diameters [9].

Before commissioning, "accidents" can also occur under certain circumstances if impurities inadvertently get into the newly constructed pipework. Examples of this are sludge ingress during storms or accidents. If a restrained joint was not installed properly and has opened during the pressure / leak test, sludge ingress is always to be expected. In such cases, intensive cleaning of the affected pipeline section is necessary. comprex impulse cleaning is particularly helpful here because it is quick and easy to carry out.

Other reasons for contamination include improperly sealed components such as pipelines, fittings or valves before installation or inadequately sealed ends of pipeline sections that have already been installed [8].

Existing drinking water pipelines with turbid water

Substances build up in existing pipework during operation. These can lead to turbidity in the drinking water if there is an increased demand for water that results in an increased flow rate. Old steel and cast-iron pipes without a cement mortar or plastic lining are a special case. Loose deposits of corrosion products can form in these pipes during operation. They settle when the water stagnates or flows at low velocity. They result in turbid water when the flow velocity increases. Oversized pipelines are particularly critical in areas with a declining population, for example. comprex impulse cleaning removes the cause of turbidity and creates the conditions for effective inhibitor treatment in critical pipe networks, similar to old steel pipes in drinking water installations [10].

Existing drinking water pipelines with animals

In some areas, unwanted animals like aquatic invertebrates colonise the pipelines. They feed on biofilms. Climate change and decreasing water demand intensify this effect [11], especially because biofilms can grow faster as a result. comprex impulse cleaning creates clean conditions because it reliably removes biofilms and animals [12].

Existing drinking or raw water pipeline with contamination

Loose deposits provide nesting opportunities for undesirable microorganisms, especially in the event of contamination. In many cases, the operator disinfects the drinking water with chlorine as an immediate measure. However, this measure does not eliminate the cause. It is therefore necessary to first find the source of contamination and eliminate it. These are often places where water can come into contact with the outside, such as elevated tanks, air valves or hydrants. The next step is intensive cleaning, e.g. with the comprex process, to remove impurities, biofilms and deposits.

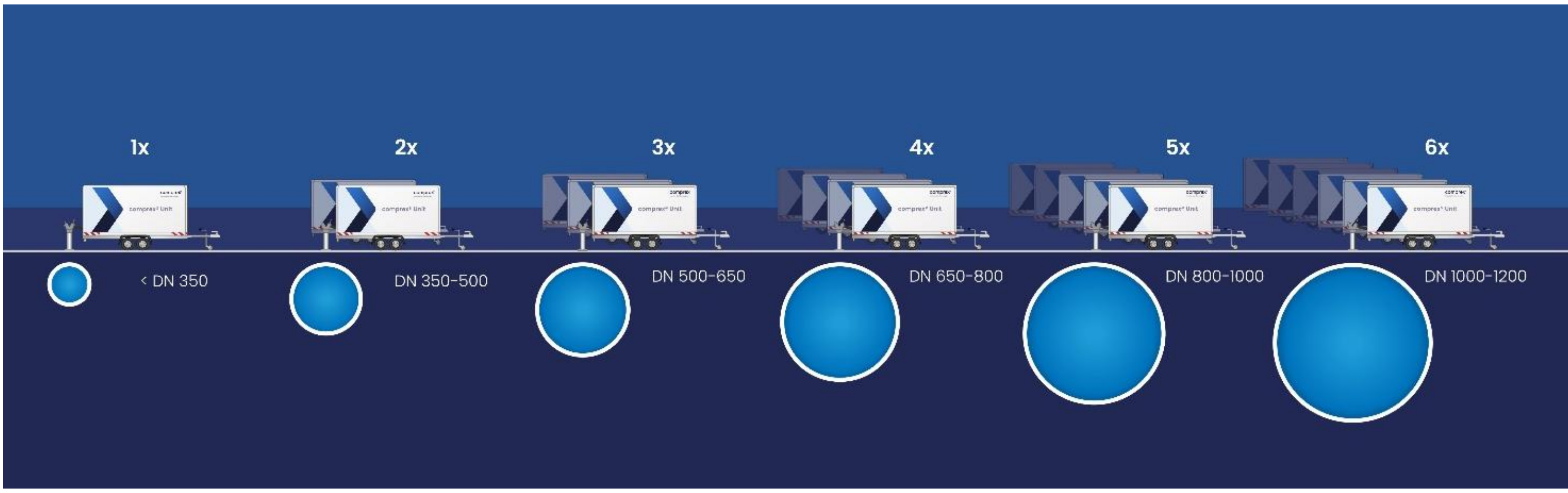

Figure 10: Number of comprex units depending on the nominal diameter of the pipework

Existing raw water pipelines with deposits

Both well and transport pipelines for water accumulate deposits during operation. comprex impulse cleaning can restore the condition of these pipelines [13]. Several synchronised comprex units are used for pipelines with larger nominal diameters (Figure 10). However, it is also possible to add inert gas such as nitrogen from cylinders as a supplement [7].

Figure 11 shows removed pipeline sections from an old asbestos cement pipe before and after comprex impulse cleaning. The pictures show the effectiveness of comprex impulse cleaning even in pipework made of fragile materials.

Figure 11: Raw water pipeline made of asbestos cement before and after comprex impulse cleaning

Wastewater pressure pipelines

The comprex pulse flushing process always works "online" in pressurised wastewater pipelines, i.e. during live operation [4]. The discharged particles reach the wastewater treatment plant and are disposed of there without any further effort. A distinction must be made between one-off basic cleaning of the entire wastewater pressure pipeline and regular maintenance cleaning.

In contrast to stationary compressed air flushing in accordance with DWA-A 116-3 [14], which has little cleaning effect, especially in long pipelines, comprex technology is mobile and can be used specifically on individual pipeline sections. This makes it possible to intensively clean critical areas such as culverts to reliably remove even large particles such as stones (Figure 8). Such stones can cause damage to the pipeline invert (Figure 7) [5]. Other large particles can even block culverts [15].

Changes in nominal diameter are also no obstacle for comprex pulses. Unlike pigs, comprex pulses adapt to the geometry of the pipeline and cannot get stuck. Even heat exchangers, which are used to recover heat from wastewater, can be reliably cleaned. The daily performance of comprex impulse cleaning depends primarily on the nominal diameter and degree of contamination of the wastewater pressure pipeline. It can be 1 km/d for basic cleaning of very narrow pipelines and up to 3 km/d for maintenance cleaning.

comprex impulse cleaning – hygienic aspect
The hygienic aspect has priority for drinking and untreated water pipelines (Table 1). Cleaning always takes precedence over disinfection. Results from BMBF joint projects [16] [17] show that mechanical cleaning is irreplaceable. *Cleaning is not synonymous with disinfection* or *effective cleaning is the prerequisite for the success of disinfection measures* or *the effectiveness of disinfection measures can be increased by accompanying physical measures.* The importance of cleaning before disinfection is also emphasised in the corresponding new regulations [18].

comprex impulse cleaning – hydraulic aspect
Deposits impair the hydraulics of pipework. The energy required to transport the water and therefore the power requirement of the pumps increases when the cross-section of the pipework narrows. Figure 12 explains the interrelationships.

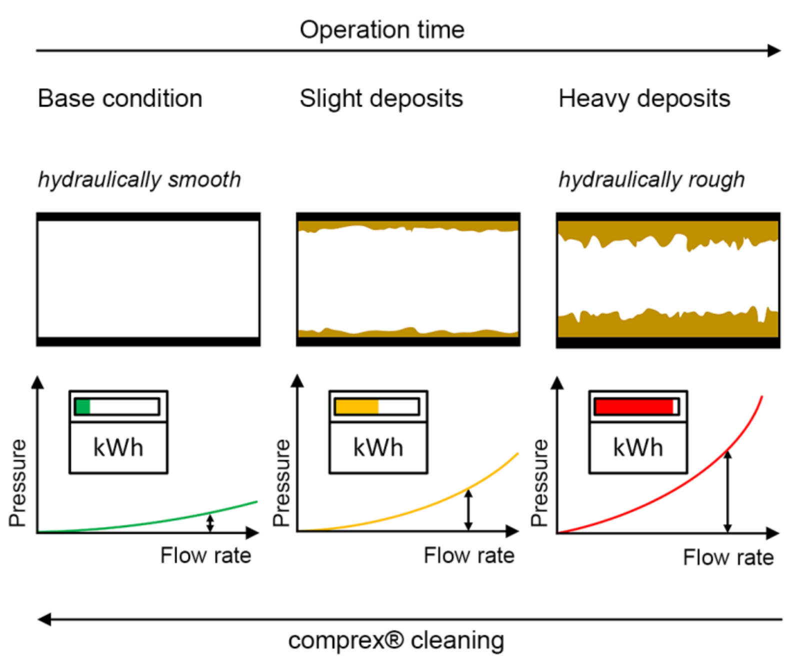

Figure 12: Relationship between deposits in pipelines and energy for water transport

The characteristic curves provide information about the condition of the pipework. This information is quite easy to determine if pressure gauges and flow meters are available. Figure 13 illustrates the hydraulic conditions using pipework characteristic curves. The new DWA worksheet A-113 also addresses this [3].

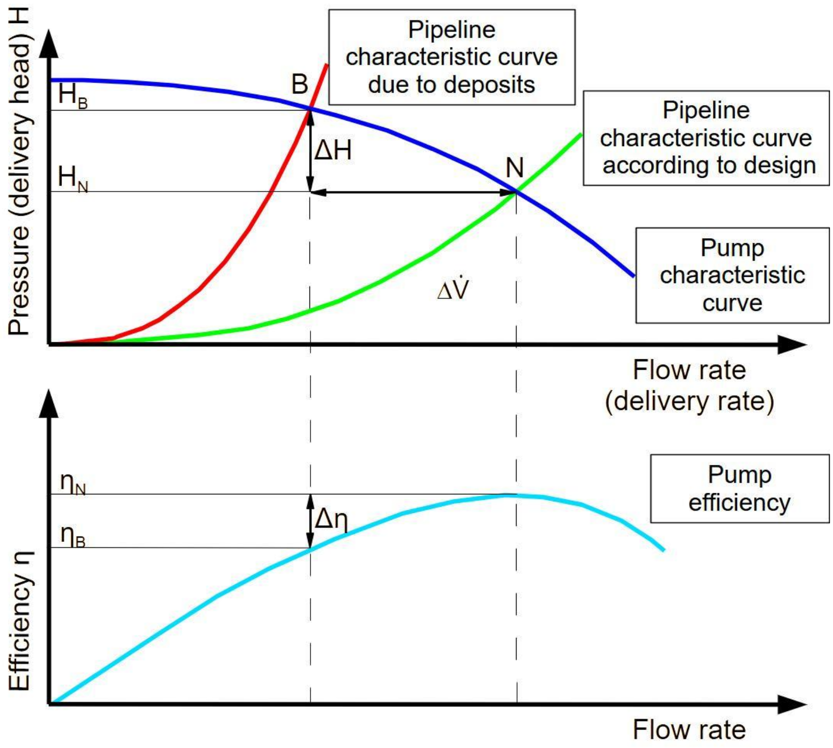

Figure 13: Relationship between pipeline characteristic curve, design characteristic curve and pump efficiency

As can be seen in Figure 13, the delivery pressure increases as the cross-section of the pipeline narrows due to deposits. At the same time, the volume flow (flow rate) decreases. The efficiency of the pump also decreases. Decreasing volume flow (flow rate) means longer pumping times for the same water volumes or quantities. comprex impulse cleaning improves the hydraulic condition of the pipework. In pipelines with deposits, the pumping times are reduced after cleaning. Figure 14 impressively illustrates on a 2.81 km long DN 125 wastewater pressure pipeline how the pumping time is almost halved after comprex impulse cleaning [4]. Cleaning wastewater pressure pipelines pays off [19]. The costs for cleaning are often amortised after just a few months.

Figure 14: Wastewater volume and pump runtimes on a 2.81 km long DN 125 PVC wastewater pressure pipeline before and after comprex impulse cleaning.

The research project REINER showed that there is also potential for saving energy in drinking water networks through comprex impulse cleaning [20].

comprex impulse cleaning – safety aspect

Restoring hydraulic conditions in pipework through cleaning increases safety for the operator. Clean raw water pipelines ensure that waterworks have sufficient water available for treatment in times of increased drinking water demand. After comprex impulse cleaning, raw water pipelines no longer contain loose deposits that can be mobilised during increased flow rates and clog filters prematurely.

Deposits in pressurised wastewater pipelines impair performance, meaning that disposal is no longer guaranteed when there is an increased volume of wastewater. comprex condition-based cleaning supports the operator in technical safety management.

The safety aspect plays a role in drinking water pipelines and networks, especially in the event of a fire. Clean pipework and functioning fittings are essential for network safety. For this reason, valve inspection complements comprex impulse cleaning.

comprex netcare – operational security

Thorough cleaning of drinking water pipelines using the comprex process, for example, requires pipeline sections to be taken out of service. This is an opportunity to check the function of the shut-off valves and to upgrade non-functioning gate valves and butterfly valves. comprex netcare combines comprex impulse cleaning with valve inspection and condition-based maintenance. The first step is to locate the valves marked on the plan. It is often the case that road caps are over-asphalted or fittings are not accessible. Inaccessible means, for example, that gate valves or underground hydrants are permanently parked up or that the valves are located in a cordoned-off area. The second step is to inspect the gate valves and hydrants and check their function. After the functional check, further measures are required for valves that no longer close. Hydrants may need to be repaired or even replaced. Valves that no longer close can often be repaired. It is always amazing how many refurbished valves continue to work.

The combination of valve inspection with condition-based training and comprex impulse cleaning ensures that all deposits mobilised during this measure are reliably removed. In addition to this hygienic aspect, comprex netcare is also interesting from an economic point of view. As it is not necessary to replace trained gate valves, there is a saving for each civil engineering measure saved, which in most cases compensates for the costs of cleaning [21] [22].

comprex netcare also makes it possible to update the planning and maintenance documents. Maintenance cycles for valve inspections can be optimised based on current data. While the interval can be extended for functioning gate valves, a more frequent inspection of the movement and stroke of successfully upgraded gate valves allows trends to be recognised. So instead of the previous procedure of carrying out the work at fixed intervals, the new procedure has the potential to save costs and increase operational safety.

Another combination with comprex impulse cleaning is hydraulically supported condition monitoring for drinking water distribution. For this purpose, special vehicles are used to record characteristic data on volume flow, pressure drop and turbidity during water withdrawal. Based on this data, it is possible to identify critical areas in the drinking water network. Recommendations based on this hot-spot analysis include prioritising certain pipeline sections for comprex impulse cleaning.

Outlook

Research projects helped to optimise the comprex pulse flushing process. Two European patents on modulating operation and optimising the control system through data feedback are based on the results. The control software in the comprex units and modules is developed in-house. If required, it can be adapted to new applications, for example for data transmission and further data acquisition. The aim of all these measures is to provide the operator with data in a compact form.

The website www.comprex.de not only serves as a library for technical articles and reference sheets relating to comprex impulse cleaning, but also provides information on news and patents [23]. Videos supplement this information. Test facilities at the Landau site help to find solutions for new customer-specific tasks.

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Summary:
The comprex process is the pulse flushing process developed by Hammann. Starting with pipe network flushing, its area of application in the municipal sector has expanded to include the cleaning of transport pipelines for raw water, drinking water pipelines and the cleaning of pressurised wastewater pipelines. The article presents the process in the various applications and explains the hygienic as well as the hydraulic and safety-relevant aspects of comprex impulse cleaning. References to the Hamman website and relevant literature provide the reader with further insights into other areas of application for the process, such as drinking water installations in buildings or in industry.

Contact:

Hammann GmbH &
Hammann Engineering GmbH
Albert-Einstein-Straße 14a
76829 Landau in der Pfalz
Germany
info@comprex.de
www.comprex.de

IES Utilities Group Limited
Sandfold House, Sandfold Lane,
Levenshulme,
Manchester
M19 3BJ
0161 791 1496
United Kingdom
info@iesutilities.co.uk
https://iesutilities.co.uk/