COMPREX IMPULSE FLUSHING PROCESS - FOR CLEANING PIPES

The Comprex process is an impulse flushing process further developed by Hammann GmbH. The range of applications of the process has gradually expanded: from pipe network flushing in the municipal sector to the cleaning of transport pipes for raw and drinking water as well as well pipes and the cleaning of wastewater pressure pipes. Comprex netcare combines cleaning with valve inspection and condition-based maintenance, thus contributing to operational safety.

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Hammann GmbH has been cleaning pressure pipes using the impulse flushing method for over 20 years. It all began with pipe network flushing in the municipal sector, with the focus on pipes with nominal diameters of DN 80 to DN 200. The effectiveness of the process quickly became known. More and more applications such as the cleaning of transport pipes, raw water pipes and well pipes were added. Larger nominal diameters required more powerful cleaning units. The development from the original pipe network flushing with air and water to efficient Comprex *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 pipes. This ultimately led to involvement in research projects.

However, more and more inquiries also came from the industrial sector. It became apparent that, in addition to pipes for a wide variety of applications, 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 in production lines.

Fig. 1 Comprex unit on Lake Lucerne Uniqe

Comprex au lac des Quatre-Cantons

roads. A new addition is industrial plant engineering for special *Comprex units* in various industrial sectors [1].

The sphere of activity expanded constantly. The units are now in use throughout Europe. In Switzerland, too, the German company regularly cleans pipelines and apparatus in both the municipal and industrial sectors *(Fig. 1)*. This article mainly deals with cleaning with the impulse flushing process in the municipal sector, in particular pipe networks and pressure pipes for drinking water supply.

and wastewater disposal.

CLEANING OF DRINKING WATER PIPES

The applications of the Comprex *method* are diverse. Although the procedure can vary depending on the application, the principle is always the same.

First of all, it is necessary to define cleaning sections with inlet and outlet points. *Figure 2* explains the cleaning principle using the example of a pipe for drinking water distribution. Here, the cleaning sections are separated by shut-off valves.

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RÉSUMÉ

COMPREX POUR LE NETTOYAGE PAR IMPULSION

Le procédé Comprex désigne le nettoyage par impulsion développé par l'entreprise Hammann.

Its field of application, after starting with the nettoyage of the réseaux, is expanding in the municipal sector, firstly to the nettoyage of large pipes transporting fresh and potable water and then to the nettoyage of drainage pipes for drainage. The exposé presents the procedure in the various cases of application. It describes the aspects of the Comprex nettoyage, both from a hygienic and hydraulic point of view and in terms of safety. The reader can find other applications of the process, such as for potable water installations i n buildings or for industry, by referring to the Hammann company's website and the relevant literature.

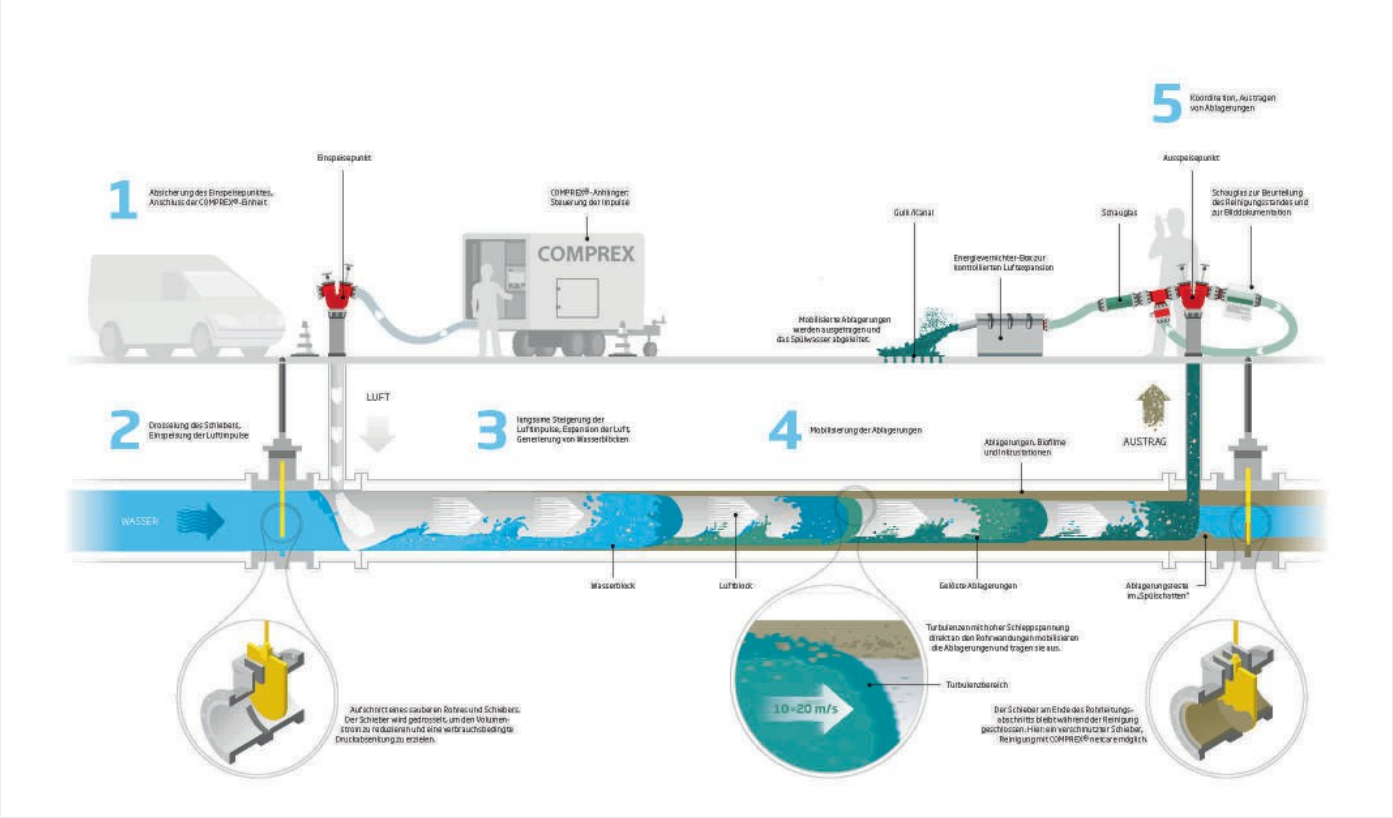

Fig. 2 Cleaning principle on a section of a drinking water pipe
Principe du nettoyage Comprex sur une section de conduite d'eau potable

mainly gate valves. Inlet and outlet points are hydrants. In the case of underground hydrants - as shown in *Figure 2* - standpipes are required. The unit is located at the feed 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.

Cleaning takes place in several phases. First, the cleaning section is set to a partially filled state by throttling the inlet valve and carefully applying compressed air from the unit *(Fig. 3)*. During the entire process, the pressure always remains below the operating pressure of the pipe to be cleaned.

The actual cleaning process then begins. Compressed air is metered into the partially filled pipe section by the unit's control software. There, the air can expand abruptly and thus form pulsating, cleaning-effective packets of water and air blocks. The effectiveness of the cleaning initially depends on the speed at which these packets move through the pipe. In the 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 h a v e a decisive influence on the effectiveness of cleaning. To form blocks, the surface of the water at rest in the pipe invert is brought up to speed in fractions of a second. Acceleration and velocity together affect the drag stress. In the Comprex *process*, this is

Fig. 3 Unit at a feed point Unité à la bouche d'alimentation

orders of magnitude higher than with simple water flushing.

When cleaning drinking water pipes, no drinking water is available from the cleaning sections during the measure. Residents are informed of this in advance. While conventional water flushing requires a lot of water and there is therefore a risk of pressure drop and turbidity in the neighboring pipe network, the water requirement for *Comprex cleaning* is much lower. This means that residents in the neighboring distribution network receive clean drinking water. Neither turbidity due to swirling sediment nor pressure losses affect the supply.

Cleaning is always carried out systematically with a clear water front. The water for cleaning comes from a clean or purified pipe.

Low water consumption also means low flushing water consumption. This is particularly important for pipes with a large nominal width, if this is not permitted, directly discharge particle-laden rinse water. As the *Comprex process* is a mechanical process, simple sedimentation is sufficient to treat the rinse water. The settled particles can be disposed of without great effort. Before cleaning measures, especially for complex

Pre-planning is always required for pipe networks. This allows a speedy cleaning procedure 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 so-called flushing shadows.

Fig. 4 Inlet points for compressed air in waste water pressure lines
Bouches d'alimentation pour air comprimé dans les conduits de refoulement

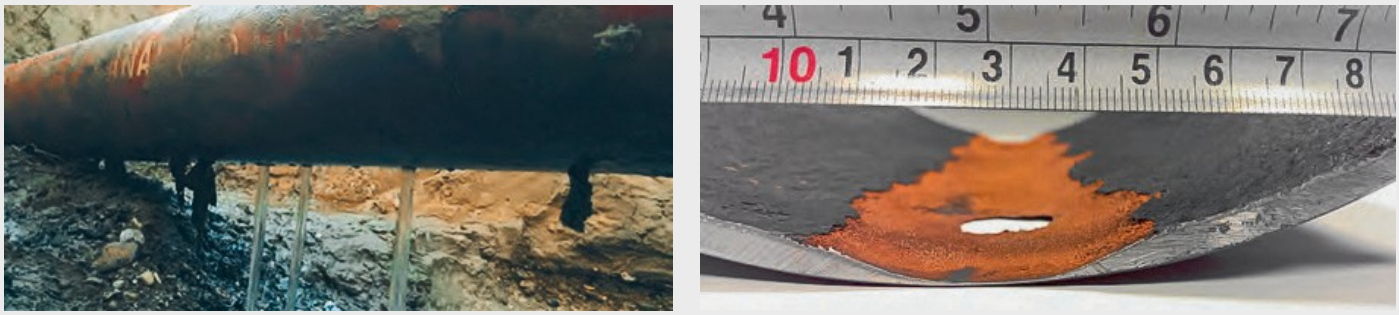

Fig. 5 Pipe perforations due to abrasion of coarse particles in the base area [4] Perforation de tuyau suite à l'abrasion par des particules grossières dans le fond [4]

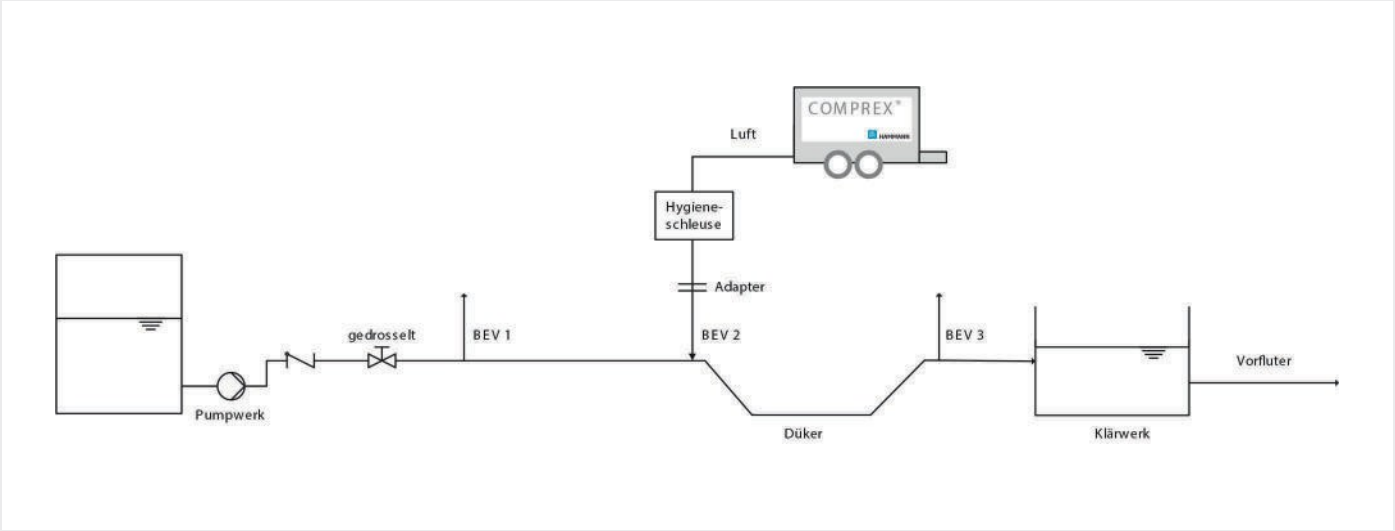

Fig. 6 Cleaning a siphon in a wastewater pressure pipe Nettoyage d'un siphon dans une conduite de refoulement

Furthermore, pipe sections that have already been cleaned can be vented before recommissioning.

CLEANING OF WASTEWATER PRESSURE PIPES

In contrast to drinking water pipes, there are no hydrants in waste water pressure pipes. Here, connections for air release valves (BEV) or drains are used to feed in the compressed air *(Fig. 4a-b)*. The discharge point is normally located at the end of the waste water pressure line. It is either the outlet into the sewage treatment plant or into a sewer, usually in a manhole.

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

In contrast to the drinking water network, cleaning begins at the feed-in point furthest away from the pumping station with the water from the pumping station. On the one hand, the water column between the pumping station and the feed-in point cannot be compressed, so that the pulses can optimally clean the last section to the feed-out point. On the other hand, a clean pipe with an optimum cross-section is available for cleaning the other sections. Particularly critical areas of a wastewater pressure pipe are culverts [2, 3]. Here, debris or stones can lead to problems. *Figures 5a and b are from* a recently published article [4]. In this case, coarse particles led to breakthroughs in the sole area as a result of abrasion.

Figure 6 illustrates the cleaning at the culvert. After cleaning the section between BEV 3 and the sewage treatment plant, the culvert is cleaned. The unit feeds the compressed air pulses at BEV 2 into the water coming from the pumping station. This ensures that coarse particles are reliably removed. Research reports [5] and practical experience with large-diameter pipes [6] prove the reliability of the Comprex *process* for this task. In contrast to the cleaning of drinking water pipes, the cleaning of wastewater pressure pipes has the advantage that the measure can be carried out during operation, i.e. "online" [3]. The wastewater accumulated at the pumping station is used together with the pulses to clean the pipe. This means that there is no downtime during cleaning. In contrast to pigs, there is also no risk of sticking because the air and water blocks adapt to any geometric shape of the pipelines.

The blocks with their high drag tensions generate strong shear forces that act on the deposits. The innovative, patented *Comprex control system* modulates these blocks in such a way that, on the one hand, they achieve high drag stresses in the cleaning section to mobilize the deposits and, on the other hand, they completely and reliably discharge the mobilized particles *(Fig. 7)*. The impulse pressure always remains below the operating pressure of the pipe in order to avoid damage.

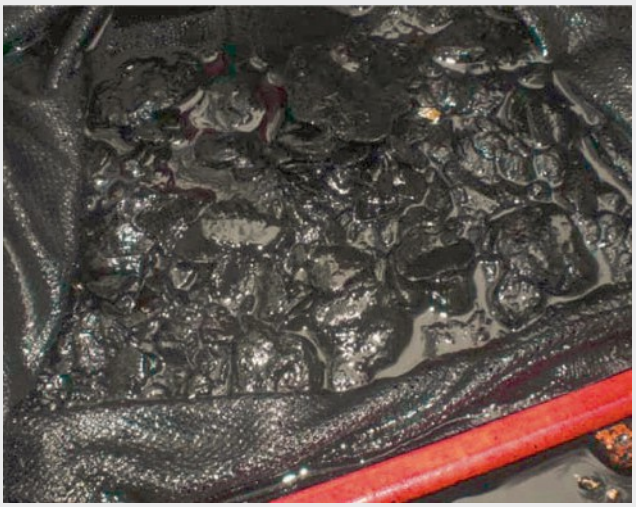

Fig. 7 Aged grease deposits from waste water pressure pipe a f t e r cleaning

Dépôts vieillis de matière grasse en provenance d'une conduite de refoulement après nettoyage Comprex

APPLICATIONS

The reason, task and purpose for an impulse flushing process are different *(Table 1)*. In the case of drinking water pipes, the hygienic aspect has priority, and in the case of wastewater pressure pipes, the hydraulic aspect. In the case of untreated water pipes as well as wastewater pressure pipes, the safety aspect and the possibility of saving pump energy play an increasingly important role.

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

Newly built trink or raw w a t e r lases

Newly constructed pipelines contain auxiliary installation materials and impurities resulting from the construction process. In the drinking water supply

Type of pipe	Occasion	Task	Purpose
Newly constructed drinking or raw water pipe	Commissioning	Remove assembly-related auxiliary materials and impurities	Hygienically perfect condition
Existing drinking water pipe	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 pipe	Contamination	Remove deposits and fouling	Prerequisite for disinfection
	Reduced flow rate	Remove deposits	Improve hydraulics, reduce pump energy
Sewage pressure pipe	Reduced flow rate	Remove deposits	Improve hydraulics, reduce pump energy

Tab. 1 Reason, task and purpose of a Comprex cleaning depending on the type of pipe Raison, tâche et but d'un nettoyage Comprex selon la nature de la conduite

In many countries, newly constructed pipe sections for raw or drinking water must be cleaned before commissioning in order to ensure that they are in perfect hygienic condition [7]. Disinfection is then often no longer necessary, which can be particularly advantageous for pipelines with large nominal widths [8].

Before commissioning, "accidents" can also occur under certain circumstances if impurities inadvertently enter the newly constructed pipeline. An example of this is sludge ingress during storms or accidents. If a restrained joint was not installed properly and has opened during the leak test, sludge ingress is always to be expected. In such cases, intensive cleaning of the affected pipe section is necessary.

Other reasons for contamination are, for example, improperly sealed components such as pipes, fittings or valves before installation or inadequately sealed ends of pipe sections that have already been installed [7].

Existing trinkwaterleaseswiththe water

Substances build up in existing pipes during operation. These can lead to turbidity in the drinking water if there is an increased demand for water. 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 them during operation. They settle when the water stagnates or flows at a low velocity. They cloud the water when the flow velocity increases. Oversized pipes are particularly critical, for example in areas with a declining population. *Comprex 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 [9].

Existing trinkwaters withtiers In some areas, unwanted animals colonize the pipes. They feed on biofilms. Climate change and decreasing water demand are exacerbating this effect [10], mainly because this biofilms can grow faster. Cleaning creates clean conditions because it reliably removes biofilms and animals [11].

Existing trink or raw water lingwith contaminations

Loose deposits provide opportunities for unwanted microorganisms to settle, 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 such as elevated tanks, aerators and deaerators or hydrants.

Existing raw water lease withd evelopments

Both well and transport pipes for raw water accumulate deposits to a greater or lesser extent during operation. Comprex cleaning can restore the condition of these pipes [12]. Several synchronized units are used for pipes with larger nominal diameters *(Fig. 8)*. However, it is also possible to add inert gas such as nitrogen from cylinders as a supplement [6]. *Figure 9* shows pipe sections removed from an old asbestos cement

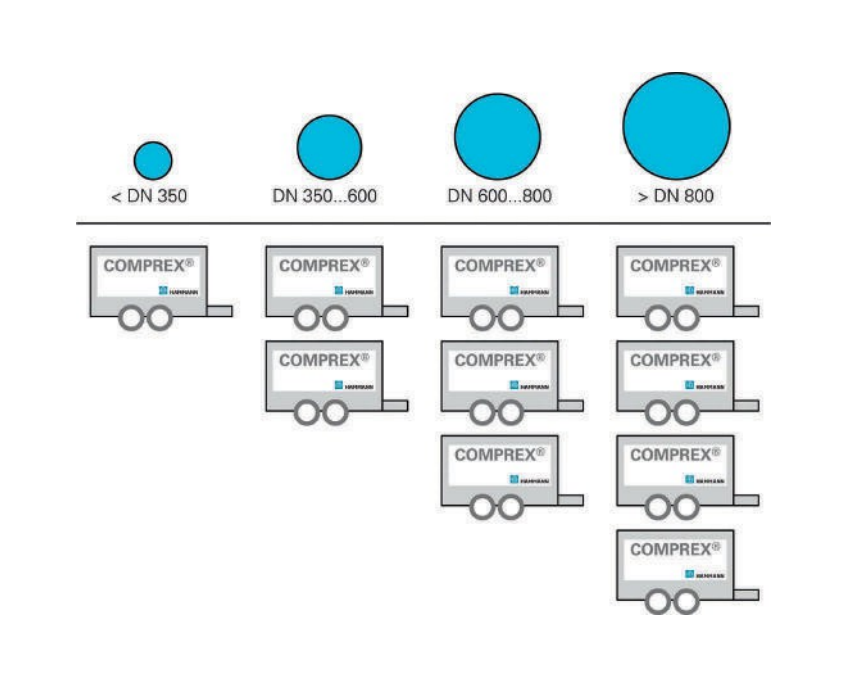

Fig. 8 Number of Comprex units depending on the nominal diameter of the pipe Nombre d'unités Comprex selon la largeur nominale de la conduite

Fig. 9 Raw water pipe made of asbestos cement before and after cleaning Conduite d'eau brute en amiante-ciment avant et après le nettoyage

and after *Comprex cleaning*. The pictures show the effectiveness of the cleaning process, even in pipes made of fragile materials.

Advassible pressure lines

The impulse flushing process generally works with wastewater pressure pipes "online", i.e. during operation [3]. The discharged particles enter the wastewater treatment plant and are disposed of there without any further effort. A distinction must be made between the one-off basic cleaning of the entire wastewater pressure line and regular maintenance cleaning. In contrast to stationary pressure air flushing in accordance with DWA-A 116-3 [13], which has only a limited cleaning effect, especially in long pipes, the technology is mobile and can be used specifically on individual pipe sections. This makes it possible to intensively clean critical areas such as culverts in order to reliably remove even large particles such as stones *(Fig. 6)*. Such stones can cause damage to the pipe invert *(Fig. 5)* [4]. Other large particles can even block culverts [14].
Changes in nominal diameter are also no problem for the air and water blocks. Unlike pigs, they adapt to the geometry of the pipeline and cannot get stuck. Even Heat exchangers, which are used to recover heat from wastewater, can be cleaned reliably. The daily output depends primarily on the nominal diameter and degree of contamination of the wastewater pressure pipe. It can be 1 km/d for basic cleaning of very narrow pipes and up to 3 km/d for maintenance cleaning.

HYGIENIC ASPECT

The hygienic aspect has priority for drinking and untreated water pipes *(Table 1)*. Cleaning always has priority over disinfection. Results from research projects show that mechanical cleaning is irreplaceable [15, 16]. The importance of cleaning before disinfection is also addressed in the relevant new regulations [17].

HYDRAULIC ASPECT

Deposits impair the hydraulic properties of pipelines. The energy required to transport the water and therefore the power requirement of the pumps increases when the cross-section of the pipe narrows. *Figure 10 explains* the relationships.
The pipeline characteristics provide information about the condition of the pipeline. This information is quite easy to determine if pressure gauges and flow meters, e.g. MID, are available. *Figure 11* illustrates the hydraulic ratios using piping characteristics. The new DWA worksheet A-113 also addresses this [2].
As can be seen in *Figure 11, the* delivery pressure increases a s the cross-section of the pipe narrows due to deposits. At the same time, the volumetric 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 cleaning* improves the hydraulic condition of the pipe. In pipes with deposits, the pumping times are reduced as a result of cleaning. *Figure 12* impressively illustrates on a 2.81 km long DN 125 wastewater pressure pipe how the pumping time is almost halved after cleaning [3]. Cleaning wastewater pressure pipes pays off [18]. The costs for cleaning often pay for themselves after just a few months. There is also potential for saving energy by cleaning drinking water networks, as the "Reiner" research project has shown [19].

SAFETY ASPECT

Restoring hy- draulic conditions in pipes through cleaning increases safety for the operator. Clean untreated water pipes ensure that in times of increased drinking

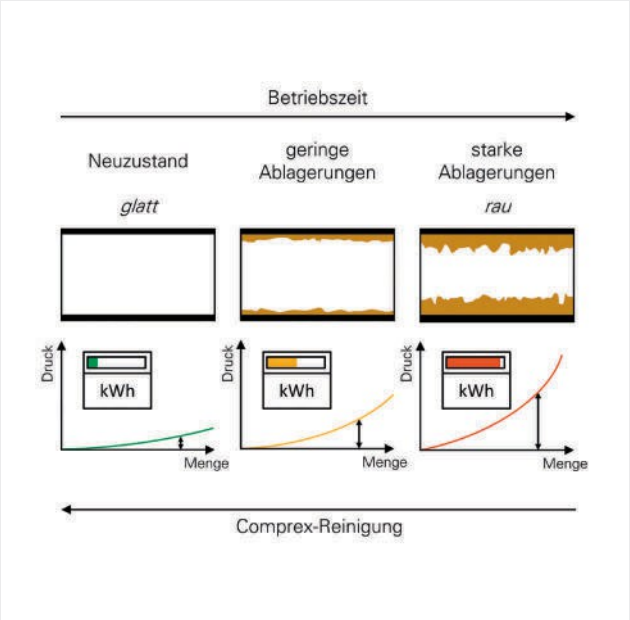

Fig. 10 Relationship between deposits in pipes and energy for water transport
Lien entre les dépôts dans les conduits et l'énergie nécessaire au transport de l'eau

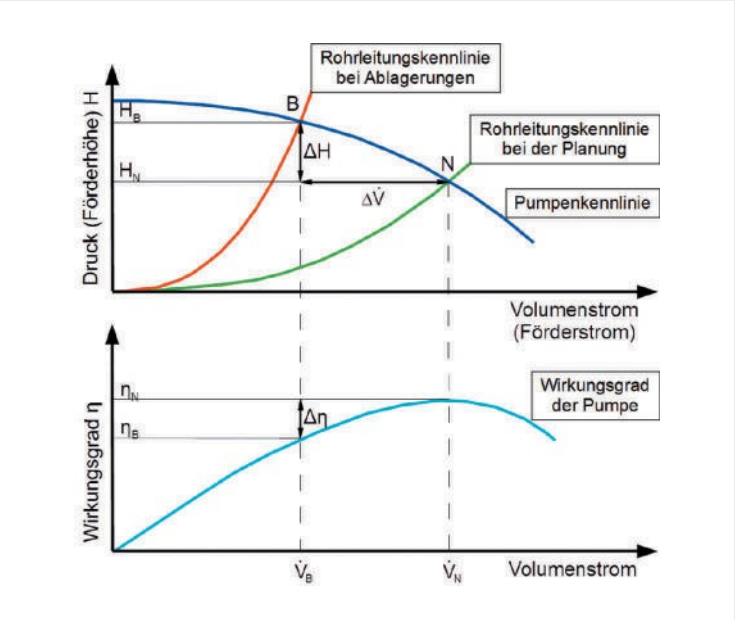

Fig. 11 Relationship between pipe characteristic curve, characteristic curve and efficiency of the pump
Lien entre courbe caractéristique de la conduite et courbe caractéristique de la pompe ainsi que son rendement

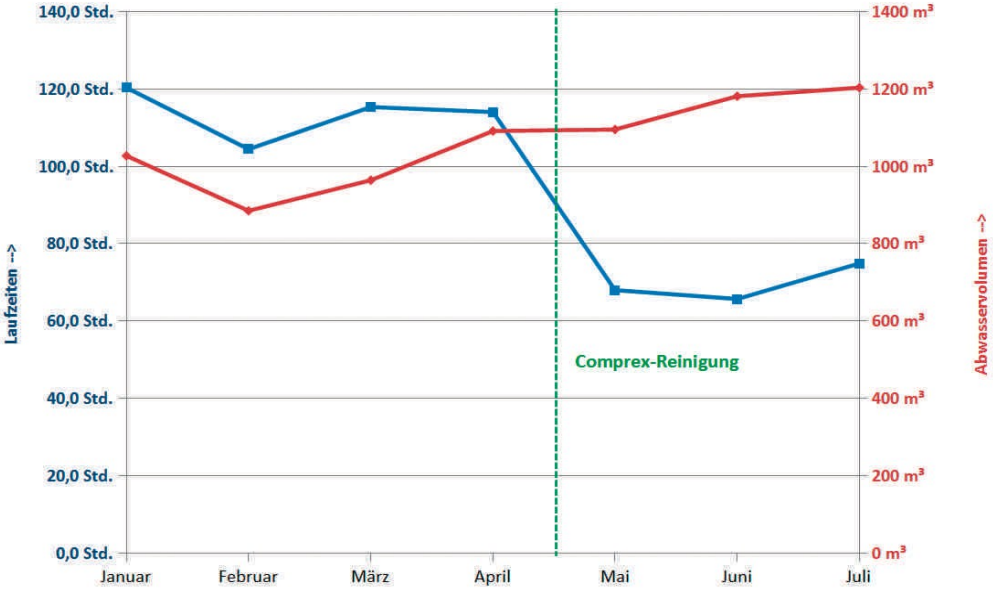

Fig. 12 Wastewater volume and pump running times on a 2.81 km long DN 125 wastewater pressure pipe made of PVC before and after cleaning Volume d'eau usée et durées de fonctionnement de la pompe sur une conduite de refoulement de 2,81 km DN 125 en PVC avant et après le nettoyage

waterworks have sufficient water available for treatment. After cleaning, raw water pipes no longer contain loose deposits that can swirl up at increased flow rates and clog filters prematurely.

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

The safety aspect plays a role in drinking water pipes and networks, especially in the event of fire. Clean pipes, but also functioning fittings, are a prerequisite for network safety. For this reason, valve inspection complements cleaning.

COMPREX NETCARE - OPERATIONAL SECURITY

Thorough cleaning of drinking water pipes requires pipe 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 *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 asphalted over 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, if the valves no longer close, further measures must be taken.

measures are necessary. Hydrants need to be repaired or even replaced. Valves that no longer close can often be refurbished. It is always astonishing how many refurbished valves continue to do their job.

The combination of valve inspection with condition-oriented refurbishment and cleaning ensures that all deposits mobilized during this measure are reliably removed. But apart from this hygienic aspect, *it is* also interesting from an economic point of view. As it is not necessary to replace refurbished gate valves, there is a saving for each civil engineering measure saved, which in most cases compensates for the costs of cleaning [20, 21]. *Comprex netcare* also makes it possible to update the planning and maintenance documents. Maintenance cycles for valve inspections can be optimized based on current data. While the interval can be extended for functioning gate valves, a more frequent check of the smoothness and stroke of successfully upgraded gate valves allows trends to be identified. This means that instead of the previous procedure of carrying out work at fixed intervals, the

FURTHER INFORMATION

The *Hammann GmbH* website not only provides information about news, but also serves as a library for technical articles and reference sheets relating to *Comprex* cleaning. Videos supplement this information. Test facilities at the Landau site help to find solutions for new customer-specific tasks.
http://comprex.de

The new approach has the potential to save costs and increase operational safety.

OUTLOOK

Research projects helped to further optimize the pulse flushing process. The results are the basis for two European patents on modulating travel and optimizing control through data feedback. Newly developed control software is already running in the *Comprex units* and modules. Prototypes for wireless data transmission and data acquisition are about to be tested in practice. The aim is to make even more data available to the operator in a compact way.

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