Comprex® netcare: intelligent maintenance with high sustainability

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Condition-based maintenance of water supply networks allows resources to be used in a targeted and therefore economically sensible manner. The Comprex® netcare maintenance concept can make an important contribution here: cleaning with the patented process ensures qualitative, hygienic and ecological network safety. In addition, the special training and the associated rehabilitation of the valves ensure technical network safety. Effective cleaning also makes it possible to improve the hydraulic conditions within the pipeline and thus minimize the energy required for water transport.

In terms of quality, Germany's drinking water has been one of the best in the world for years. The approximately 6,000 water suppliers are responsible for ensuring that this is the case and, above all, that it remains so in the future.

Anchored in law in the Drinking Water Ordinance and embedded in the DVGW regulations, quality assurance is one of the main tasks in the daily practice of water suppliers. The systems for the production, storage and distribution of drinking water must be constructed and operated in accordance with the recognized rules of technology in such a way that no quality-reducing factors are present or can arise. As the systems are subject to natural ageing and wear processes, they require regular maintenance and servicing. This area ties up a considerable amount of the utility company's financial and human resources.

The pipe network deserves special attention here. On the one hand, this is due to the fact that the pipe network is generally the largest item in the fixed assets of a utility company. On the other hand, the pipe network fulfills several functions at the same time: it is the transport route, means of transport and, above all, the "packaging" of the drinking water.

There is another important aspect: while the supplier can have a direct influence on the quality of drinking water during its extraction, treatment and storage, there are no or only very limited opportunities to do so on the way to the consumer, i.e. in the pipe network. In addition, there are "external" factors that can also not be influenced by the water supplier:

" Demographic change and changes in consumption behavior ("water-saving mentality") lead to lower consumption volumes and longer retention times/stagnation with the known problems.
" Better sampling methods mean that positive findings are more frequent and require a corresponding response from the water supplier.
" Increasing demands in the administrative area and on employee qualifications cost additional time and money.
" Improving the revenue situation by adjusting water prices is generally not wanted (in terms of business) policy or is difficult to implement.

The core problem that arises from this can be simply formulated: The financial and human resources of water suppliers cannot be expanded at will or even tend to decline; at the same time, more time and money would have to be invested in the maintenance and servicing of the pipe network in particular in order to maintain quality and security of supply in the long term.

The logical consequence is that utility companies must use the available resources as intelligently and efficiently as possible. Maintenance must be condition-oriented and sustainable. Only then is it possible to extend the useful life of the pipe network, minimize the costs of repairs and spread out the investments for renovation or renewal over time.

The Comprex® netcare maintenance concept pursues precisely this objective. What advantages and benefits does it offer utility companies? The name Comprex stands for a sophisticated, highly efficient and at the same time very gentle cleaning technology that can be used to remove all mobilizable deposits from pipes. It is used wherever normal flushing methods (water, air-water) reach their limits or do not achieve the desired sustainability.

The technology is based on the proven pulse flushing process, which has been on the market for more than 17 years. In recent years, the specialist company has been able to gain decisive insights for the further development of the technology through intensive, scientifically supported analysis of the process sequences and by participating in various BMBF and BMWi-funded research projects.

development of the process. In July 2014, the European Patent Office granted a patent for a "process for removing deposits and/or biofilms in a pipeline using modulating pressure pulses". The basic mechanisms of the pulse flushing process are also effective in Comprex cleaning: Computer-controlled air pulses are injected into a clearly defined, pressure-reduced cleaning section (***Fig. 1***), which are dimensioned so that they form complete air blocks. The interplay between the air and water blocks creates highly turbulent flows at speeds of 10 to 20 m/s at the interfaces of the two media. The resulting shear and drag forces on the pipe wall loosen the existing, mobilizable deposits; the water flowing in ensures safe discharge.

In the further development of the Com- prex process now in use, it has been possible for the first time to modulate the air pulses in all their parameters and thus also to influence the "design" and dynamics of the water blocks. A new computer control system was integrated into the technical units, which is based on software developed in-house with very complex computer models. With the additional modulation of the air pulses, it is possible to achieve an even higher energy development within the cleaning section and thus a more even and controlled distribution of the forces at almost all points of the pipe wall.

Ultimately, this makes cleaning more thorough and more sustainable. Comprex cleaning therefore has decisive advantages for network operation compared to other flushing methods and offers several benefits for network safety:

1. **Qualitative network safety means: clear water from cleaned pipes**

Turbidity and rust water are generally the most common cause of reactive or systematic network flushing by water suppliers. On the one hand, because the permissible turbidity pa

The reason for this is that the drinking water parameters are clearly defined by the Drinking Water Ordinance and are easy to measure in practice, and also because cloudy/brown water quickly becomes apparent to the end customer and leads to the corresponding reactions/complaints.

The thorough Comprex cleaning process efficiently removes mobilizable deposits and corrosion products and thus the substances responsible for the above-mentioned quality impairment from the pipeline. As part of the BMBF joint project "Microbial fouling in technical systems", the cleaning process was able to prove its efficiency in removing fouling from raw water and well pipes.

2. **Hygienic network safety means: hygienically flawless water from clean pipes** The removal of mobilizable deposits through intensive cleaning removes microorganisms from the area of retreat. If the drinking water is contaminated, e.g. due to external events, thorough cleaning of the pipe network is one of the basic requirements for the elimination of microorganisms. disruptive factors or for successful disinfection.
3. **Ecological network safety means: water fit for human consumption without organic impairment**

Comprex cleaning removes biofilms and deposits that serve as food and shelter for animals such as woodlice. Only by thoroughly cleaning the pipes can contamination of the drinking water be eliminated or prevented.

The fact that thorough cleaning is a key factor in ensuring hygienic and ecologically sound conditions in a drinking water pipeline is demonstrated, among other things, by the findings of the BMBF joint project

"Biofilms in drinking water installations", which was carried out between October 2006 and April 2010 under the coordination of Prof. Dr. Hans-Curt Flemming (Biofilm Centre and IWW Zentrum Wasser) and with the participation of Hammann GmbH.

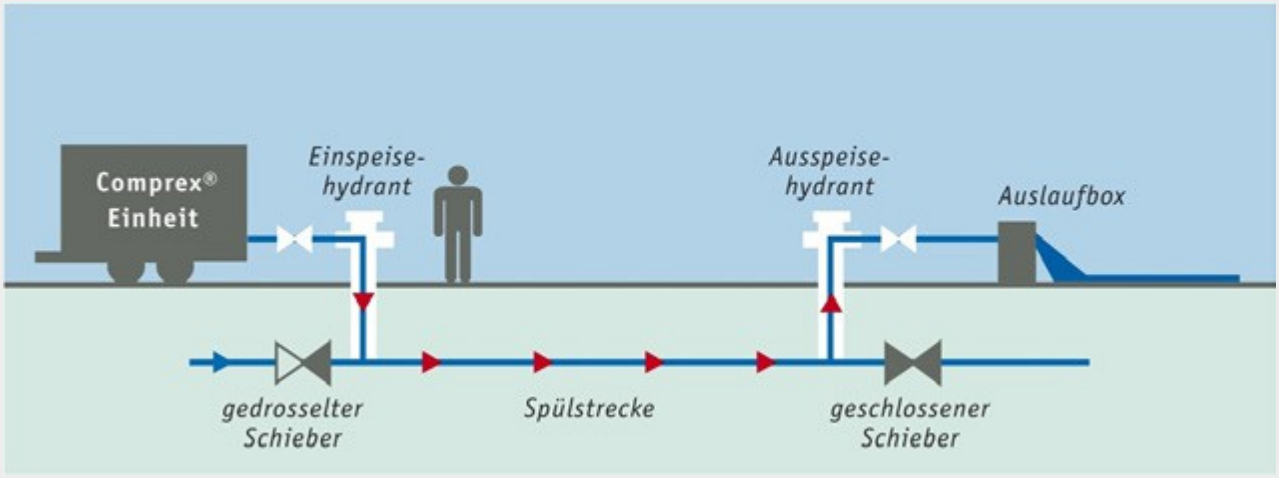

***Figure 1**: Diagram of the Comprex® process*

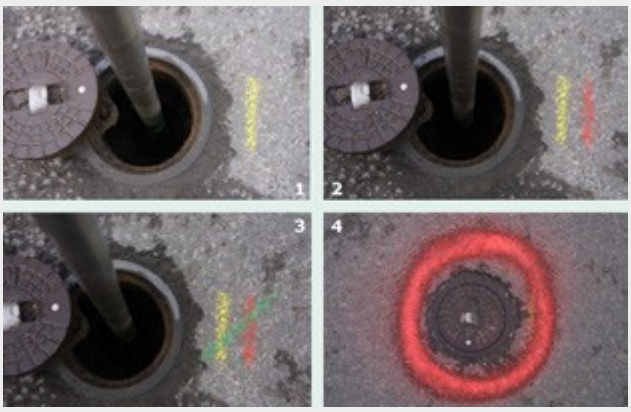

***Figure 2**: Comprex® netcare markings: 1 = gate valve tested, 2 = gate valve tested and defective, 3 = gate valve upgraded, 4 = gate valve defective - structural measures required*

***Figure 3**: Soft-sealing gate valve, photo credits: TU Berlin, FG Fluid System Dynamics; DVGW research project W8/02/10 "Condition-based maintenance of underground valves in water distribution"; with kind permission*

A pilot study conducted by the Institute for Groundwater Ecology at the University of Koblenz-Landau in 2012 with a focus on water isopods also impressively demonstrated the positive effects of removing the biofilm using Comprex cleaning [1]. In the cleaned network section of the water supplier involved in the study, the population of the animals was reduced by almost 99 %. The low recolonization two months after the cleaning also indicates that the cleaning removed the animals' food source and thus combated the actual cause of the infestation.

4. **Technical network security**

In addition to cleaning, the main focus of the Comprex® netcare maintenance concept is on the shut-off valves. This is less about the activities to be carried out as part of valve maintenance in accordance with DVGW Code of Practice W 392 (in future W 400/3 Supplement B1, still in draft form). Rather, it is about the core function of the shut-off valves, namely the tightness of the system.

Almost everyone who works in the pipe network is familiar with the following situation: You have to shut off a section or a certain area due to construction work or a burst pipe and the first valve you operate is stiff and/or not tight. Sometimes it takes three or four attempts to find a functioning gate valve. This takes a lot of time and the supply interruption then affects a much larger area than would have been the case if the first valve had fulfilled its core function. As a rule, the valves that are localized in this way and defined as non-functional are subsequently replaced.

The maintenance concept includes checking all section valves for leaks in the system and targeted, condition-based training of the valves in order to restore the core function. This work can be planned and carried out without time pressure because consumers have been informed of the supply interruption required for cleaning by means of announcements in the press and flyers.

All inspection and cleaning measures are comprehensively documented - with a clear marking system (***Fig. 2***) and with a written log of all processes. This provides the supply company with well-founded information about the actual condition of the pipe network, which can be incorporated into further maintenance planning.

The positive economic effect should not be forgotten: a shut-off valve that demonstrably fulfills its core function again after appropriate training does not need to be replaced. A rehabilitation rate of 60-70 % of the processed gate valves on average means considerable savings potential for the utility company.

An example: In October 2011, as part of an initial pilot project (five working days), Stadtwerke Steinfurt had a network section of approx. 6.4 km cleaned using the Com- prex method and carried out valve maintenance and rehabilitation (65 gate valves and 45 hydrants) with its own personnel. Of the 30 valves that no longer fulfilled their core function, 23 (77%) were upgraded. The economic evaluation of the pilot project produced the following result[2]: Internal costs of the supplier: €9,500
Costs of Comprex cleaning: € 7,000
Saved replacement costs:
approx. € 40,000 (cost estimate per gate valve approx. € 1,750) Total savings: approx. € 23,500 The combination of pipe network cleaning and condition-based gate valve maintenance has proven to be consistently positive.

***Table 1**: Soft-sealing gate valve, source: TU Berlin, FG Fluid System Dynamics; DVGW research project W8/02/10 "Condition-based maintenance of underground valves in water distribution"; with kind permission*

Actuation no.	Max. Torque AIG [Nm]	Spindle revolutions [l]	Leakage flow [l/min]	Acceleration amplitude [g]	Torque [Nm]
1	50	4,91	-	-	4,38
2	50	20,01	122,52	3,01	3,94
3	50	20,15	70,68	1,52	3,33
4	50	20,2	61,26	0,01	3,63
5	50	20,24	47,12	0,79	3,21
6	50	20,25	37,7	0,6	3,14
7	50	20,24	47,12	0,71	2,76
8	100	20,54	0	0,03	2,97

tive effect on technical grid security is also shown in a study by the University of the Federal Armed Forces in Munich [3]. Under the leadership of Dr.-Ing. habil. Steffen Krause and Dipl.-Ing. Christian Platschek, a survey was carried out among ten Bavarian water supply companies, summarizing their experiences with the use of the maintenance concept.

During the evaluated measures, a total of 654 hydrants and 1,246 gate valves were checked for functionality. Around 15% of the valves were found to be non-functional. Thanks to the special procedure, 2/3 of the valves were rehabilitated and therefore did not need to be replaced.

Assuming average costs of between € 1,500 and 2,500 for a valve replacement, companies were able to save around € 280,000 in investment and installation costs. In addition, more than 30% of all the valves inspected were easier to operate. These preventative measures ensure that the gate valves retain their functionality permanently or at least for a significantly longer period of time.

Another positive effect was that the systematic processing of the sliders deepened the network knowledge of the supplier's employees. Any existing errors in the planning work become apparent and can be corrected. And the measure also has an overall positive effect on the normal operation of the network, as the supply has to be interrupted less to replace valves.

A recently completed DVGW research project dealt with the topic of "Condition-oriented maintenance of underground valves in water distribution". Under the direction of Prof. Dr.-Ing. Paul Uwe Thamsen from the TU Berlin and with eight large water utilities as project partners, typical cases of damage to underground valves were scientifically investigated, analyzed and evaluated in the laboratory in order to create a condition diagnosis.

The water suppliers provided both metal-seated and soft-seated gate valves. The damage caused by incrustations and deposits was particularly surprising in the case of the latter. All the more surprising was the fact that even soft-sealing gate valves (see ***Fig. 3***) could be rehabilitated by simple training and deposits removed so that they would close reliably again.

Table 1 shows just how important the last half turn of the spindle is in order to get a gate valve really tight, albeit only as an example, but very clearly. To explain: The gate valves provided in their original condition (after removal from the existing network) were installed in a specially developed test system with which the conditions in a pipeline in operation were simulated. During the closing processes (training) of the gate valves, the flow rate was measured, designated as leakage flow (l/min) in the table.

With the second closing process and 20 spindle rotations, a high leakage flow of 122.52 l/min was detected. With a quarter turn more after seven closing operations, the flow rate had reduced to just over a third (47.12 l/min). The valve was only 100% tight (0 l/min) with a further quarter turn on the eighth and final actuation. The Comprex® netcare maintenance concept ultimately works in exactly the same way as the project tests: The decisive factor for defining the tightness of a gate valve is the water leakage at the nearest hydrant downstream of the processed valve. The closing processes are repeated until no or at least a technically controllable water leakage is detected.

5. **Energy-efficient grid operation means saving energy with optimally cleaned cables**

The topic of energy efficiency plays an important role in many areas of daily life today. Large amounts of energy are also wasted in the drinking water supply.

***Image 4**: Cham - before - after*

energy is required to extract the water, treat it and transport it to the consumer via the distribution network. When it comes to saving energy and therefore costs when pumping drinking water, the main focus is on optimizing pump performance. In water extraction, however, it has been common practice for years to clean not only the pumps but also the raw water pipes, which are very often contaminated with large amounts of iron and manganese deposits, as part of well regeneration. There is probably no need to explain that cleaning the pipe in the condition shown - here a raw water pipe in Cham before and after cleaning (***Fig. 4***) - saves considerable energy costs.

However, it can also be assumed that consistent and systematic cleaning will improve the hydraulic conditions in the distribution network, allowing the pumps to handle the same flow rates with less energy and therefore lower costs.

The research and development project "Increasing energy efficiency in water networks through new assessment tools and optimized purification" (REINER), which began in May 2015, aims to shed more light on this issue. The joint project is part of the BMBF funding measure "KMU-innovativ: Ressourcen- und Energieeffiz- enz" in the technology and application area "Sustainable Water Management (NaWaM)". The project, initiated by Hammann GmbH, is being realized in collaboration with RWW Rheinisch Westfälische Wasserwerksgesellschaft mbH from Mülheim an der Ruhr and the Chair of Mechanics and Robotics at the University of Duisburg-Essen.

The project has two core objectives:

" On the one hand, the Comprex cleaning control system is to be extensively optimized in order to significantly increase cleaning performance once again. The cleaning process is to be controlled in real time, depending on the measured variables at the discharge point, using a newly developed measuring box.

" On the other hand, newly developed analysis and verification tools will be used to generate statements on the hydraulic condition and possible energy savings. The results should then lead to a service package consisting of pipe network analysis, calculation of possible energy savings, verification of the energy savings achieved and optimized implementation of cleaning. Ideally, a detailed pipe network analysis can be created based on the pipe network analysis. This should identify individual pipe sections with high energy requirements and correspondingly high energy saving potential in a complex pipe network.

Conclusion

Drinking water is the "No. 1 foodstuff" in Germany and therefore requires the greatest possible efforts on the part of water supply companies in order to permanently ensure quality in accordance with legal requirements and the provisions of the DVGW regulations. As human and financial resources are limited or declining, the maintenance of water supply systems - and the pipe network is of particular importance here - must be carried out as efficiently as possible.

The basic prerequisite for efficient maintenance is knowledge of the condition of the systems and the pipe network. Only through condition-oriented work can resources be used in a targeted and therefore economically sensible manner. The Comprex® netcare maintenance concept can make an important contribution here.

Based on a sophisticated, highly efficient cleaning technology, coupled with the special handling of the shut-off valves, the water supply company not only receives a pipe network that has been cleaned with a high level of sustainability, but also a wide range of information about the condition of the pipes.

pipes and the installation parts. Ideally, there is a direct transfer of knowledge through the interaction between the service technicians and the water supply company's network experts.

The Comprex® netcare maintenance concept is beneficial for water supply companies in several ways: cleaning with the patented process ensures qualitative, hygienic and ecological network safety. Added to this is the technical safety of the network thanks to the special training and the associated rehabilitation of the shut-off valves. Effective cleaning also makes it possible to improve the hydraulic conditions within the pipeline and thus minimize the energy required for water transport.

Literature

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KEYWORDS: Water supply, Asset management, Maintenance, Impulse flushing process

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