Cleaning the raw water pipes secures the drinking water supply

Not only the wells must be regularly regenerated, but also the raw water pipes to the waterworks can represent a critical area for operations and may require regular cleaning. Depending on the water quality, cleaning measures should therefore be included in the company organization. Two examples show the effectiveness of the Impuls flushing process (COmprex' process) for upgrading untreated water pipes.

Rahwater from surface water or groundwater is the raw material for the drinking water supply. Raw water pipelines transport the raw water to the water treatment plant. The demand for drinking water varies from year to year and from day to day. The supply of raw water fluctuates accordingly. At peak times, raw water pipelines transport up to the maximum designed volume flow, while at times of low demand, the water in the pipeline stagnates.

Several pumps often feed a raw water pipe with water of different compositions. Pumps and pipelines were coordinated with each other during planning, and the control system switches the operation of the pumps according to demand. As water consumption has declined in recent years, the downtimes of the pumps and the stagnation times of the raw water in the pipelines have increased.

Raw water can contain elevated levels of iron and manganese. These elements are present in the reduced form as divalent ions. During water treatment, these ions are oxidized with atmospheric oxygen, precipitated as insoluble hydroxides and removed via filters. If the filters are loaded and the flow rate is no longer sufficient, it is necessary to backwash and re9generate the filters.

Depending on the mode of operation and type of raw water, oxidation and precipitation may already take place before water treatment due to traces of dissolved oxygen. Known are V0f-

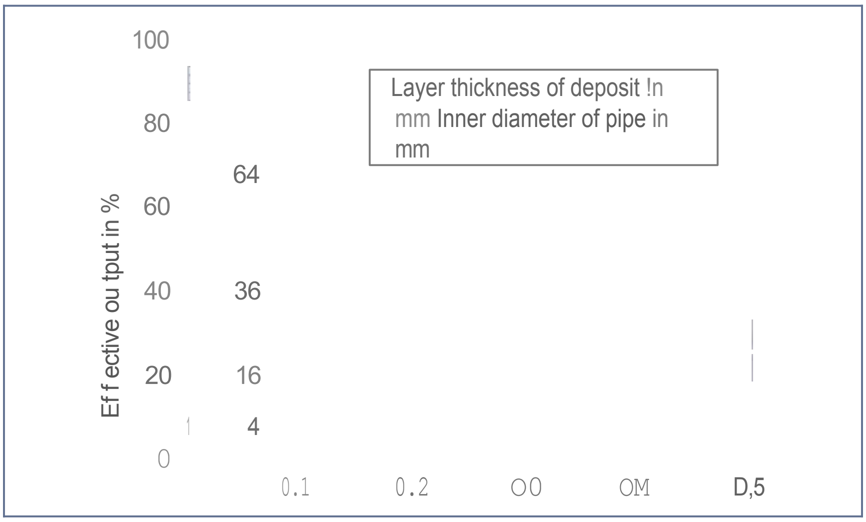


Fig. 1: Cross-sectional narrowing during overgrowth of a pipeline

elle: HAMMA Wasser-K

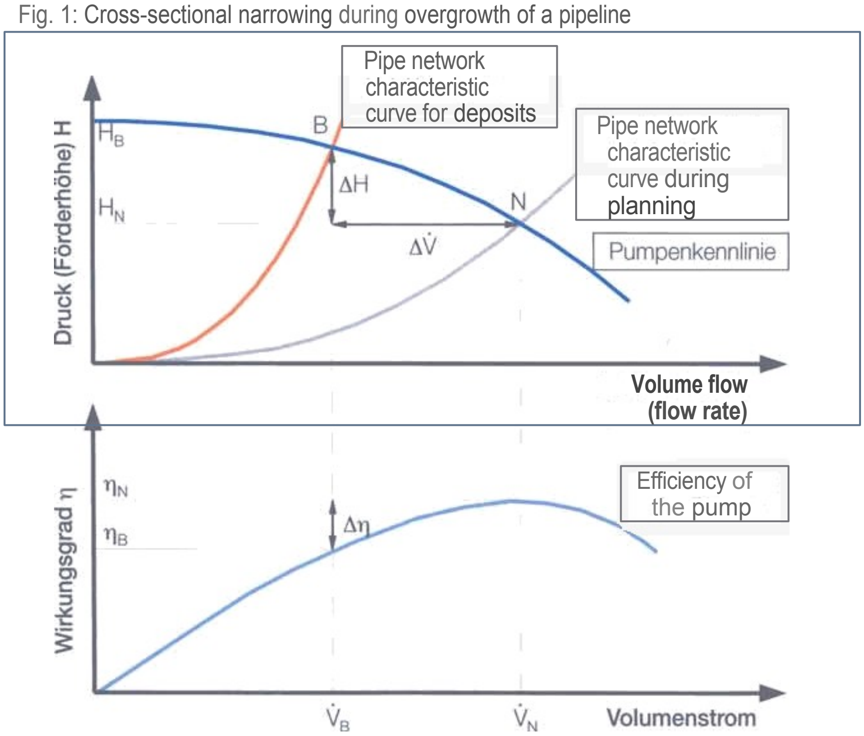


Fig. 2: Pipe line and pump characteristic curve with efficiency of the pumpa

sser-K m

wells, which have to be regenerated at regular intervals. Less attention is usually paid to the degradation in raw water pipes. These occur depending on the pipe material and have a negative effect in two main ways:

- Impairment of hydraulics: Deposits reduce the cross-section of the pipeline: the pipeline grows too.
- Impairment of the water quality: With a high water demand and the resulting increased flow velocity, deposits impair the water quality through turbidity.

Figure 1 shows how deposits narrow the cross-section of a pipe. For example, in a pipeline with an internal diameter of 300 inrri, a layer thickness of 30 mm reduces the cross-section from 100 to 64 percent. A Vdoubling of this layer thickness to 60 mm reduces the cross-section to 36 percent.

Deposits also increase the wall rariig'xeit. Both effects influence the piping parameters and therefore the piping curve. Fig. 9 2 shows a piping characteristic curve during the planning of lgrar e curves around after bilcation of deposits {red curve). The pump was selected accordingly when planning the piping characteristic curve The pump characteristic curve (blue curves intersects the piping characteristic curve at point N. Under these conditions, the pump has its best efficiency q. If the piping parameters change over time, the intersection point of the piping characteristic curve and the pump characteristic curve changes to the point B. This increases the pump pressure, while the volumetric pressure and efficiency of the pump decrease. The consequences are an increase in energy costs and ultimately an insufficient supply of raw water.

Experience has shown that deposits solidify over time. It can happen that older layers on the pipe wall exhibit higher skills than lower layers facing the water.
*/WasserÖedarf and thus large flies scnwindigkeiten can not yet dissolve and cloud the water. The moDilized substances I3elas the filters of the water arit- IJere\tung, v'zenn high I.eisiung required
\st. Jumping back the filters means Standstill periods, which are inconvenient when water demand is high.

Avoidance measures

and removal of deposits Wells and pumps are serviced at regular intervals and regenerated if necessary. This is only partially the case with raw water pipes. The following two examples show how maintenance was carried out in the past and how it can be optimized in the future with the impulse flushing process.

Measures that reduce the extent of the deposits are interesting. Their aim is to remove the poorly soluble iron and manganese compounds in the soil before extraction or to largely avoid their precipitation during extraction by means of suitable water management. For example, the recharge process can be transferred to the groundwater-bearing soil layers if a partial flow is enriched with atmospheric oxygen and fed back into the soil. In special cases, measures can be taken to pump water with reduced content of 'divalent iron and manganese ions or methane) and water containing acidic substances separately.

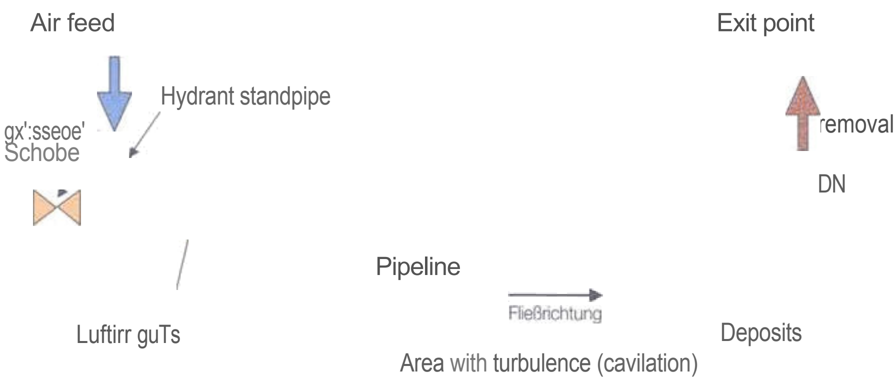


Fig. 3: Schematic diagram of the impulse flushing process (Campre& process)

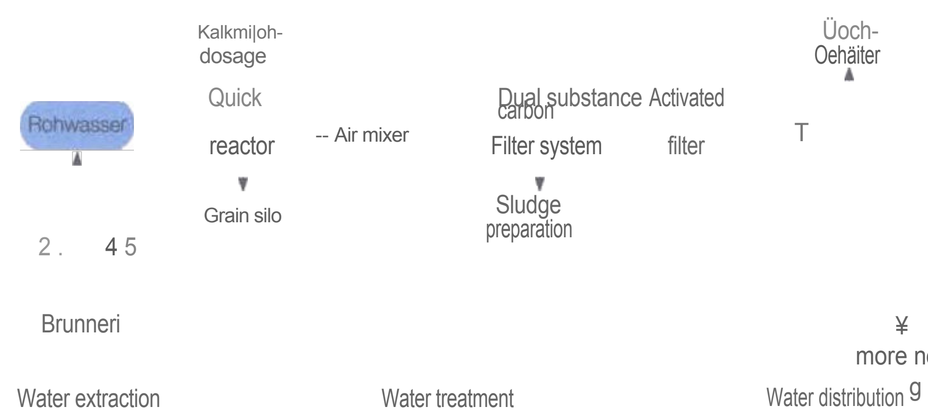


Fig. 4: Extraction and treatment of the raw water at Stacftwerke Ratingen

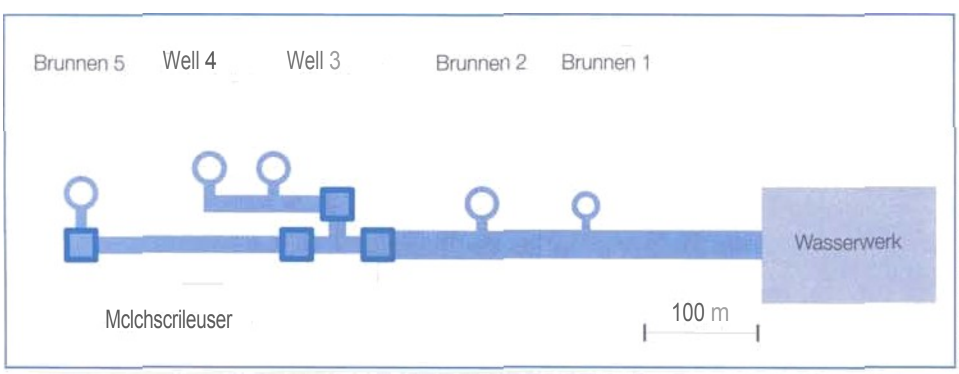
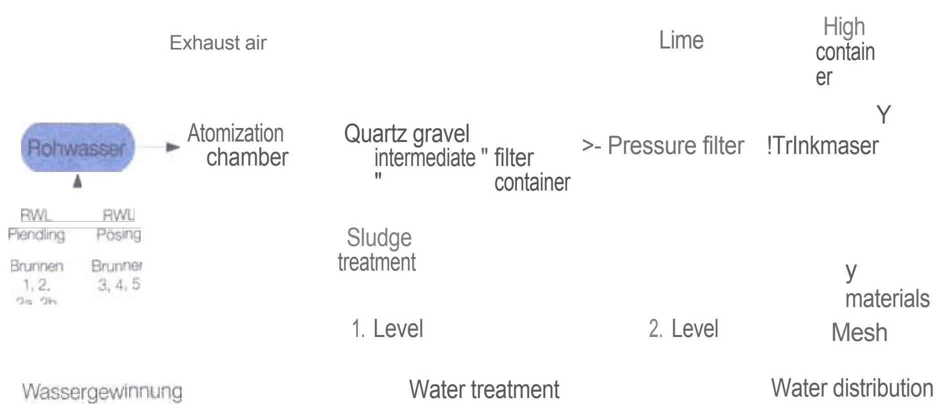


Fig. 5: Diagram of raw water purification with wells and pig sluices in Ratin9sn; line width corresponds to the nominal width of the pipeline



and sa ierstottha\tigem groundwater, largely avoid.

removal of Pigging is a widely used process for the closed deposits from raw water pipes. remove. In pipes with a nominal diameter of

150 sponge rubber balls are used

° Use. Pig launchers are required to clean larger nominal widths. The technology has become established, but is partly very complex. Conversions are therefore n e c e s s a r y for the inward and outward transfer of pigs. Several flushes are required

'ch, so that the pigs do not enter the mobili- seventh deposits or get stuck on incrustations. Pigs must be hy be technically flawless. They must not contaminants into the pipe and must be treated accordingly. If raw water pipes consist of

different nominal widths, the mol- Chen is very time- variable.

For over ten years, the pulse flush1 method has been established, initially for the

¥ Pipe network flushing, but then also more network * and more for cleaning raw water pipes. tions. In the meantime, kilometers

* Flush long pipes over DN 1000

and deposits efficiently.

The pulse flushing method (Comprex)

The Comprex process is based on a controlled, imp\ ised addition of com- p'\mated, pure air inr\erhatb a defined, pressure-reduced flushing section. It is necessary to calibrate the entire system. Based on the parameters nominal diameter of the pipe, length and course of the flushing section, pipe network resting pressure and lowered pipe network pressure, computer-assisted fourfold filtered air is injected into the flowing water. This creates air bubbles with defined lengths, which fill the entire pipe cross-section and move as air bubbles alternating with water through the pipe. the rinsing section (Fig. 3T.

Y Y The pipe is cleaned at the boundary areas of the air bubbles to water turbulent turbulence occurs there at flow velocities of 10 to 15 m/s. Local cavitation phenomena cause a

y } Sustainable replacement of all mobilizable materials

Mesh Deposits from the pipe walls. The air holes in the water flow represent the

§ Discharge of dissolved substances,

Fig. 6: Extraction and treatment of raw water Dsi Stadtwerke Cham GmbH

,

The Comprex process keeps the impulse pressure below the pipe network pressure.

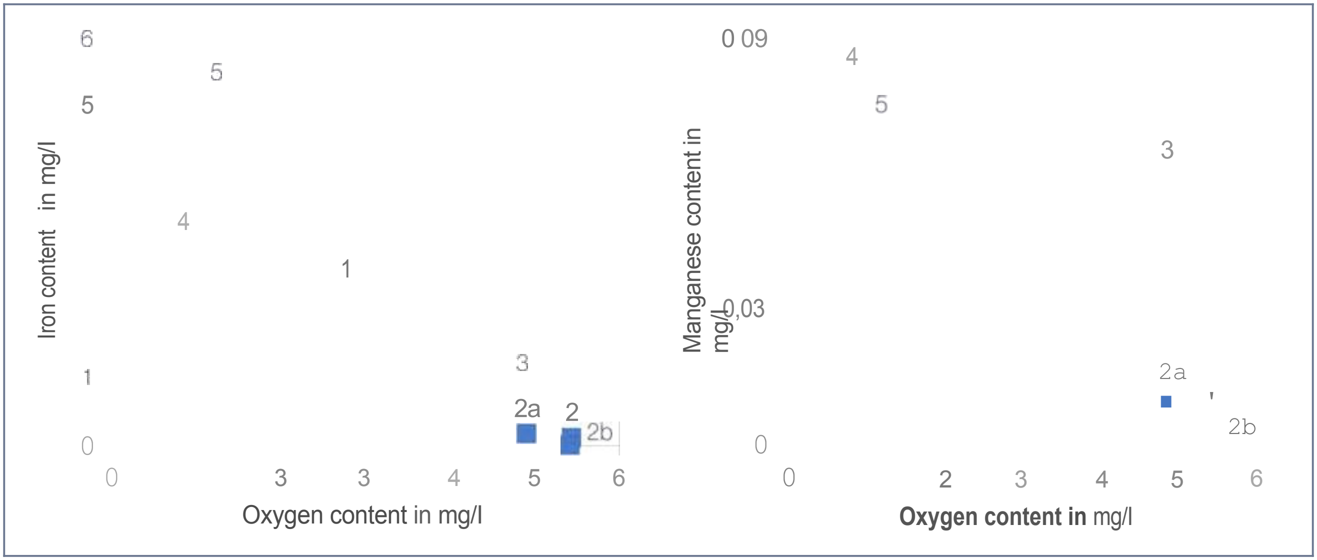


Fig. 7: Relation between oxygen and iron or manganese content in the well water from Piendl!ng and Pösing

in order to prevent the pipe system from pressure loads than in normal operation. Damage is practically impossible as a result.

Practical example 1: Stadtwerke Ratingen

Stadtwerke Ratingen obtains raw water from five of its own wells from a depth of 30 meters. A control system controls four large and one small pump so that the required total quantity of raw water is always available and is transported to the water treatment plant via raw water pipes. There, the water is partially softened in a fast reactor by adding milk of lime and then enriched with oxygen in an air mixer in order to oxidize the dissolved divalent iron to form heavy iron compounds. A two-substance filter system separates the sparingly soluble iron compounds.
mustard and Man9an compounds as well as remaining lime milk from the

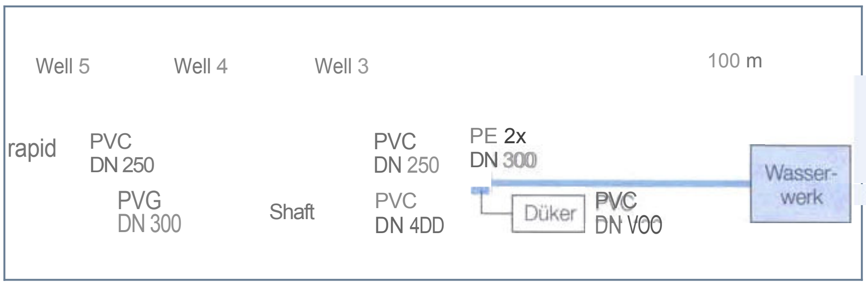


Fig. 8: Põsing raw water pipeline

reactor aD. After passing through active carbon filters, the treated drinking water is then fed into two elevated tanks (Fig. 4).

The pumps deliver very hard raw water with a high iron content. Although the five wells are close together, the waters differ in their composition, Table 1 shows the analytical values that are relevant for the formation of deposits (for comparison, the final values are also shown).

The corresponding analysis values for the treated drinking water are listed below).

Heavy iron compounds can form when the different waters are mixed and oxygen is introduced during pumping. However, they could also be present in the untreated water and separate in the event of stagnation in the pipe. There are four critical points:

w

Quell tadtwerke Cham GmbH

Fig. 9: Deposits in the AZ connection pipe of well 1

- Pumps: Cleaning once a year
- Raw water pipe: Cleaning once a year
- ReaktorDlende lime milk dosing! Cleaning once a year
- Two-substance filter system: Cleaning after two days

The raw water pipe used to be milked once a year {fig. 5). There was always the danger that the sponge could get stuck get stuck. Therefore, cleaning with the in-puls rinsing process was an interesting alternative. Further technical and economic advantages were already apparent during the first rinse. Due to the different nominal diameters from DN 150 to DN 500, three piggings were previously required.

and six employees.

The Comprex process can be adapted to the various nominal widths. The raw water pipes are cleaned in a short time, with only one employee from the steelworks present. The cleaning time, during which the pipeline is out of service, is reduced by 30 to 40 percent.

The annual cleaning of the raw water lines using the pulse flushing process has proven its worth. It ensures that sufficient water (up to 900 m"/h) is available at peak times and that the filters are not overloaded. This has a positive effect in terms of

iich of the Technical Safety Management GSM).

Practical example 2: Stadtwerke Cham GmbH

Stadtwerke Cham GmbH obtains raw water from seven deep wells. Two raw water pipelines (RWL Piendling and RWL Pösing) transport the raw water to the Wetterfeld waterworks. Fig. 6 provides an overview of the water extraction ring and water treatment.

The Wetterfeid waterworks has two treatment stages. In the first treatment stage, the raw water passes through three atomization channels onto three open water filters and from there into an intermediate tank. In the evaporation chambers, part of the carbonic acid is expelled and dissolved iron and iron oxides are removed.

ions were oxidized. The ore gravel filters retained the oxidized, poorly soluble iron compounds. If these filters are contaminated, they must be backwashed and cleaned. The resulting sludge water is treated in a sedimentation tank. The sludge, which contains iron and is dehydrated, can be recycled externally.

High-pressure pumps transport the water from the intermediate tank to the second treatment stage and finally to the high-pressure tanks. The remaining excess carbon dioxide is bound in three closed pressure filters in the second treatment stage and the water is hardened. The aim is a drinking water with a pH value of 8.3 and a hardness of approx. 1 mmol/l (5 dH). The Biber waterworks has its own small laboratory for ongoing monitoring of important parameters such as pH value, oxygen content, conductivity, carbon dioxide content and hardness.

Some of the water from the wells has very different analyses. Table 2 shows the most important analysis values for well water and illustrates the effectiveness of water treatment based on the corresponding drinking water parameters.

The water in the troughs is soft and contains calcium carbonate. They have different oxygen contents. Table 2 indicates a correlation between these parameters. In Figure 7, the values of the well water to the raw water pipe are shown.

Fig. 10: Deposits in a steel pipe in the waterworks Weather field

Juelle: Stadtwerke Cham GmbH

Fig. 1: Removal of ferrous deposits from untreated water pipes in Cham using Comprex-VeJahren

Juelle: HAMMANN Wasser-Kommunal

Piendllng are shown in blue and those for the raw water pipePösing in grey. In the case of the mustard content, a correlation can be seen. In the case of the manganese content, the high value for well 3 in relation to the oxygen content is striking.

In the case of the raw water pipeline9 from Pösing (Fig. 8), the water from well 3 has a significantly higher acidity content compared to the water from wells 4 and 5, on the one hand, and a significantly higher acidity content compared to the water from wells 4 and 5, on the other.
tends to have a lower iron concentration. When these waters are mixed, sparingly soluble compounds are formed which deposit on the inner surface of the pipe.

The raw water pipeline consists of plastic pipes. Figure 8 shows the pipe sections, the pipe materials and the nominal diameters. This pipeline was considerably silted up. The extent of this became clear when evaluating data from the regularly conducted well inspections. The pump performance continued to decrease. With increased withdrawal quantities during periods of high consumption, the current demand increased disproportionately, while the volume flow decreased sharply, especially when several pumps were operated at the same time.

A similar effect was also seen in the Qohwasse'te\tung P\endting, most notably with parallel operation of pumps 2. 2a and 2b. The situation became critical when all wells were used simultaneously. With extremely high electricity demand, the required

The required amount of water could hardly be pumped. Measures were urgently needed. First of all, three wells were regenerated.

The connection pipe at well 1 was also renewed. It consisted of AZ pipes DN 200 (AZ: asbestos cement). Figure 3 shows a pipe section of this pipeline with brown deposits. A mineralogical analysis revealed that these deposits consisted mainly of poorly crystallized ferrihydrite and small but roughly equal amounts of quartz and kaolinite. Ferrihydrite is an oxide/hydroxide of trivalent iron and is formed during the rapid oxidative precipitation of divalent iron dissolved in water at pH values > 5. Other iron oxides
e.g. hematite, goethite, lepidocrocite, maghemite or magnetite could not be detected radiographically. The partially fossilized layer was formed over time from quartz sand, the clay mineral kaolinite and the deposited iron compounds.

The extensive high-pressure cleaning of a 25-metre-long steel pipe in the waterworks upstream of the atomization chamber showed the extent of the deposits (Fig. 10) and the need for cleaning. In terms of process engineering, this procedure was not suitable for the two raw water pipes. The cornp\ette renewal was up for discussion.

Alternatively, cleaning with the impuls rinsing process should be used. This cleaning process is suitable,

Quell AMMANN Wasser-Kommunal

Fig. 13: Pipe section made of DN 350 AZ corrugation after successful pulse flushing

because the gentle but efficient flushing can mobilize and remove ferrous sludge. This argument is particularly important for pipes made of brittle asbestos cement and for special pressure-sensitive plastic pipes. With the Comprex process, *the* operating pressure is not exceeded and damaging pressure surges are avoided. Different nominal widths or even bifurcations, as with the double culvert, do not pose a problem.

The cleaning of the Pö- sing raw mass separation required four flushing sections. Working around the clock, the sludge was largely discharged after five days (Fig. 11). After flushing, the system values at the well improved

Quelle: HAMMANN Wasser-Kommunal/Stadtwerke Cham GmbH

AbD. 12: Impulse flushing for AZ pipes with hard deposits: (q} Removal of hard deposits;
(b) partially fossilized deposits

Parameters	Enheit	1	2	3	4	5	Container
Gas hardness	mmoPl	3,77	4,53	4,74	4,02	3,94	3,1
Basecapacity @, $_{S4,3}$	mmol/l	0,85	1,31	1,48	1,05	0,93	0,26
Manganese	m@l	1,2	1,2	0,78	0,39	0,25	< 0,01
gelöster Sauerstoff	mg/l	1,2	0,92	0,94	1,3	0,72	6,0

Parameters	Grace	1	2	2a	2b	3	4	5	Container
pH-Wert	–	6,25	6,03	5,32	7,03	6,05	5,65	6,13	8,2
Total hardness	mmoP	0,857	0,600	0,404	1,091	0,300	0,329	0,391	0,9
Säurekapazität $K_{S4,3}$	mmol/l	1,46	0,49	0,23	1,79	0,28	0,29	0,57	1,5
BasekapBzitdt	mmol/t	1,16	1,2B	1,56	0,64	0,91	1,17	1,17	< 0,05
gelöster Sauerstoff	mg/l	2,72	5,44	4,90	5,42	4,85	0,83	1,22	9,2
Manganese	m$4	0,027	0,007	0,011	0,@5	0,060	0,080	0,070	< 0,002

4 considerably. The delivery rate of well 3 even had to be throttled via an annular piston valve and initially adjusted in this way so as not to increase the extraction rate excessively.

Cleaning the Piendling raw water pipe proved to be more complex than the Pösing raw water pipe. Some of the deposits were already hardened. Figure 12 shows removed pieces. Residual dBr adhering deposits remained in individual sections of the pipe after dBITi normal impulse flushing and can only be completely removed with increased effort.

Figure 13 shows the success of cleaning with the Comprex process. The few remaining deposits in this AZ pipe DN 350 do not indicate any impairment of the water flow. The inlet pressure at the pumps of wells 1, 2, 2a, 2b and the power consumption are within the normal range.

Experience from Cham shows that raw water pipes must be cleaned regularly. are clean. This is the only way to ensure that the deposits do not harden and can be easily removed.

Conclusion

Raw water pipes convey the raw water for drinking water treatment in the waterworks. Just like pumps and filters, these systems must remain functional at all times; deposits can clog them to such an extent that they eventually lose their performance. If particles dissolve under high loads, the filters close at the most unfavorable time when water demand increases.

The impulse flushing method has proven its worth for years for upgrading raw water pipes. The gentle yet highly effective Comprex process mobilizes deposits and removes them. Compared to conventional pigging technology, its simplicity is impressive. Based on piping parameters, air pigs can be easily produced with computer support by adding purified air via connections such as hydrants or air vents. They adapt to the pipe

The water flows through the pipe with the same cross-section - even with nominal diameter changes - and does not get stuck. With a low flushing water requirement, the pipeline regains its planned capacity after a short cleaning time - economically, effectively and sustainably.

Examples illustrate the recent successes. The raw water in Ratingen is hard, while very rich raw water flows through the pipelines in Cham. Both raw waters have high iron contents. While the pipes in Ratingen are cleaned annually, the AZ pipe in Cham was already so overgrown that replacement was considered. The Comprex process was able to prove its efficiency and contribute to the rehabilitation of the aged pipes. Examples at Gelsenwasser and the Berlin waterworks show that even large pipelines can be cleaned. The first flushing of raw water pipes in DN 1000 and DN 1200 have been successful there.

Acknowledgments

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