HIGH PERFORMANCE DE-SANDING

for well development and regeneration in horizontally and vertically screened wells

Mit den bei der Teftorec® GmbH entwickelten Doppelkolbenkammern zur Intensiventnahme in Verbindung mit der Wasserhochdruck-Impuls-Technologie (hypop®) zur Porenraumstimulation, die gemeinsam mit der Uraca Pumpenfabrik GmbH Co. KG entwickelt wurde, können Vertikal- und Horizontalbrunnenfilter auf Basis fallspezifischer Einsatzplanung bei Neubau zielgerichtet entwickelt sowie in der Brunnenpflege und -instandhaltung optimal regeneriert und saniert werden. Die mit selbstständiger Saugstromsteuerung ausgerüsteten Spezialkammern werden seit drei Jahren in Filtern aus Stahl und Kunststoff der Nennweiten DN 175 bis DN 1000 zur Hochleistungsentsandung (HLE) eingesetzt. Auch Filterkornschüttungen können mit der hypop®-Impulstechnik konsolidiert werden. Die in Vertikalbrunnen bewährten Funktionsgruppen wurden zur wirtschaftlichen Anwendung der HLE in Horizontalbrunnen konstruktiv angepasst und zur Rehabilitierung über 50 Jahre alter Bauwerke, z. B. in Berlin und Nordrhein-Westfalen, sowie zur Aktivierung eines in der Schweiz neu errichteten Horizontalbrunnens mit gutem Kosten-Nutzen-Verhältnis erfolgreich eingesetzt.

Source: Teftorec® GmbH

Diver in the shaft of a horizontal well during the development of a well screen

With the intensive extraction chambers and impulse technology for pore stimulation developed by Teftorec® GmbH in conjunction with case-specific operational planning, newly constructed vertically and horizontally screened wells can be optimally developed and aged wells rehabilitated to restore performance.

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Since the development of the double packer chamber system, which depending on requirements is configured either as the symmetrical double packer chamber (SDKK®) or the double packer slot chamber (DKSK®), in the last few years intensive extraction chambers have been available which enable the systematic and effective cleaning of the pore spaces in the filter pack of a well and the adjacent aquifer. The basis for the system is the application of variable pumping rates in the extraction chamber that optimize the fluid mechanics for the specific section of the well screen being treated, in terms of the induced groundwater flow velocities in the pores of the filter pack and aquifer sediment **(Fig. 1)**. The results of applied research based on high-resolution numerical modelling of flow processes conducted by GCI GmbH [1, 2, 4] were confirmed in field tests [3, 5, 6]. The prerequisite for pore cleaning in the filter pack and surrounding sediment are sufficiently high groundwater pore velocities in the zones being treated. These are ensured by a capable geometry of the intensive extraction chamber and the applied pumping rates, which are calculated taking into account both the details of the well construction and the properties of the aquifer sediments.

The fine particles mobilized in the pore spaces tend to be re-deposited and may bridge pore spaces, leading to blockages of the pore channels and transport paths. As a result, dirt and fine particles remain trapped, hindering the pore cleaning process and removal of particulate mass. Thus it is necessary to continually clear these blockages by appropriate stimulation of the pore spaces during the treatment process. Using an intensive extraction chamber in combination with pressure impulse technology for stimulation of the pore spaces it is not only possible to optimally clean the gravel, sand, or glass bead filter pack, but also to remove from the borehole aureole sediment fractions as fine as to pass through the pore

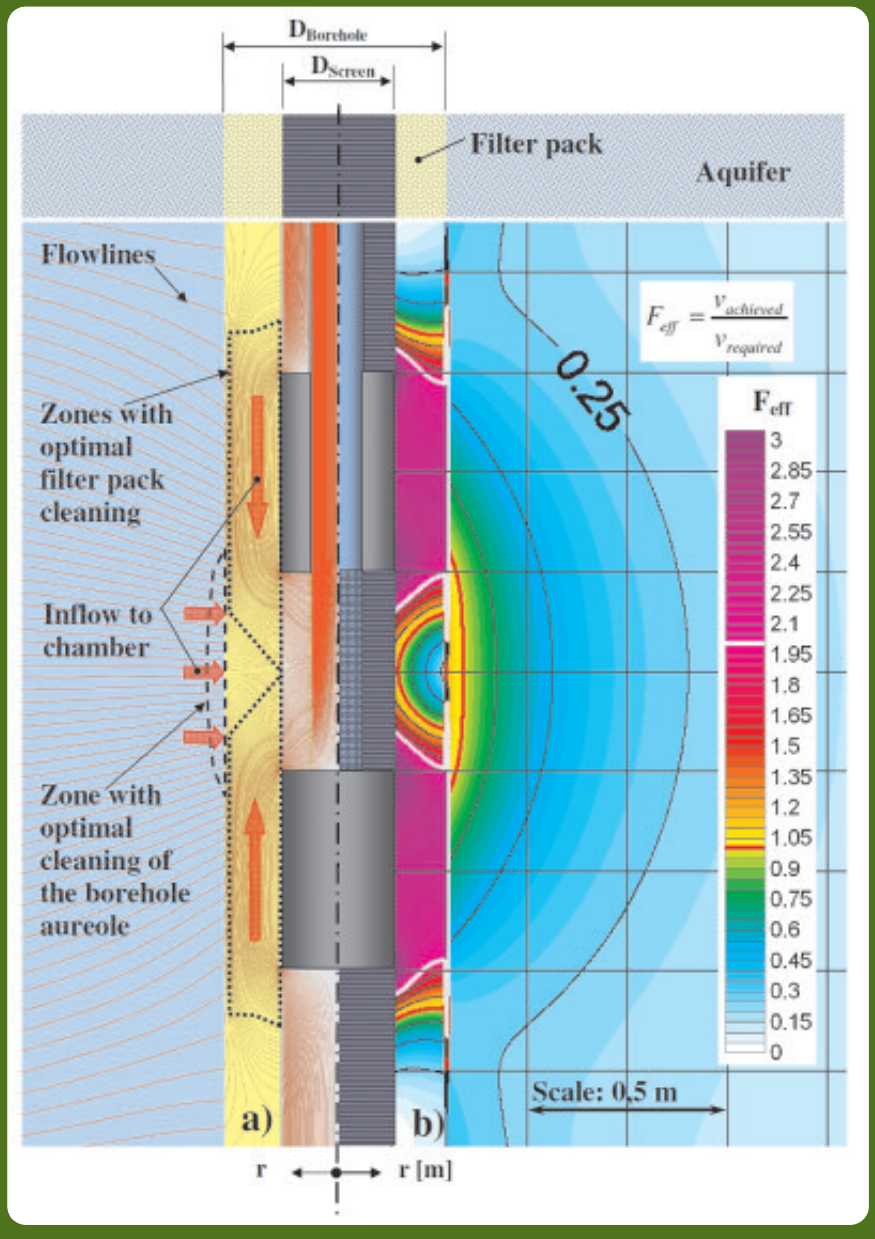
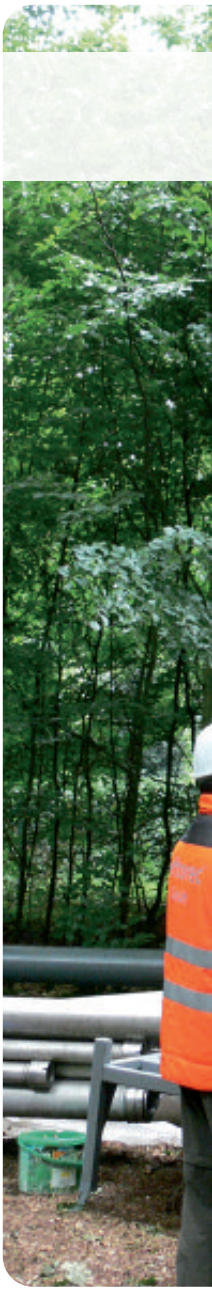


Fig. 1: Groundwater flow close to the filter for a symmetrical double piston chamber; left (a): Flowlines show the zones with optimal de-sanding; right (b): Distribution of the efficiency factor F_{eff} shows zones with a pore flow velocity sufficient for pore cleaning.



Source: Dr. P. Nillert

channels of the filter pack, as well as remnants of mud etc. from the drilling process. This results in a fluid mechanically smoother transition between the filter pack and aquifer sediment by creating a so-called support grain trestle. Depending on the sediment properties, the chamber pumping rate, the pressure impulse technology, and the application time for this high performance de-sanding (HPD, in German: „Hochleistungsentsandung" or "HLE"), fine particles (silt or fine sand) can also be removed from the sediments immediately surrounding the well, improving the inflow to the well screen. As a result, in comparison to conventional de-sanding, wells treated with HPD have a better post-treatment yield and longer lifetimes due to reduced ageing.

The deployment of a double packer chamber is carefully planned, taking into account the aquifer properties, the well geometry, and the desired results. The chamber geometry, the required pumping rates for the different well screen sections and treatment phases, as well as the de-sanding treatment goals and treatment times for each section are determined during the planning phase. This planning enables a reliable estimation of probable costs and expectable results for the HPD before going to the field.

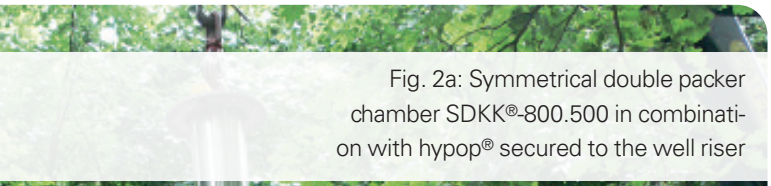


Fig. 2a: Symmetrical double packer chamber SDKK®-800.500 in combination with hypop® secured to the well riser

Fig. 2b: Standard SDKK®-800.800 with hypop® integrated within the extraction chamber

Source: Teftorec® GmbH

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The performance of the double packer chamber is fundamental to the successful implementation of the deployment plan. As a result of the typical well geometry, the inflow conditions around the well in the vicinity of an extraction chamber depend on its position in the well screen. Particularly unfavourable conditions for the cleaning of filter and sediment pores exist close to the top and bottom of the well screen. To overcome this problem, double packer chambers from Teftorec® GmbH are equipped with a patented mechanism for automatic distribution of the intake flow [7].

Double packer chambers in combination with impulse technologies have been used successfully for over three years for the development and regeneration of vertical wells with diameters ranging from DN 175 (7") to DN 1000 (40"), and constructed with steel, PVC-K and fibreglass screens at depths of up to 200 m (660 feet). Wells regenerated with HPD have regained, or in some cases exceeded, their original new-build yields. Abandoned wells with yields of 3 to 10 percent of their original value regained 20 to 50 percent of their new-build yields after moderate treatment.

In the application of intensive extraction chambers in wire wrap screens, water can flow through the gaps formed by the vertical support rods that lie between the packers and the wrapped wire that forms the screen itself, bypassing the packers and thus reducing the induced flow to the filter pack. This problem is overcome in Teftorec® packer systems through the use of special open-pore foam rubber seals which can deform around the supporting rods and so maintain an effective contact between the packer and the well screen. This ensures that practically the entire chamber pumping rate is utilized for the pore cleaning process.

Keys to the economic efficiency of HPD are the impulse frequency, which is a determining factor for the rate of particulate mass removal, and the reliability of the impulse equipment. With the Well Screen Hydro Power Pulse technology, a joint development of Teftorec® GmbH and Uraca Pumpenfabrik GmbH Co. KG, the double packer chambers coupled

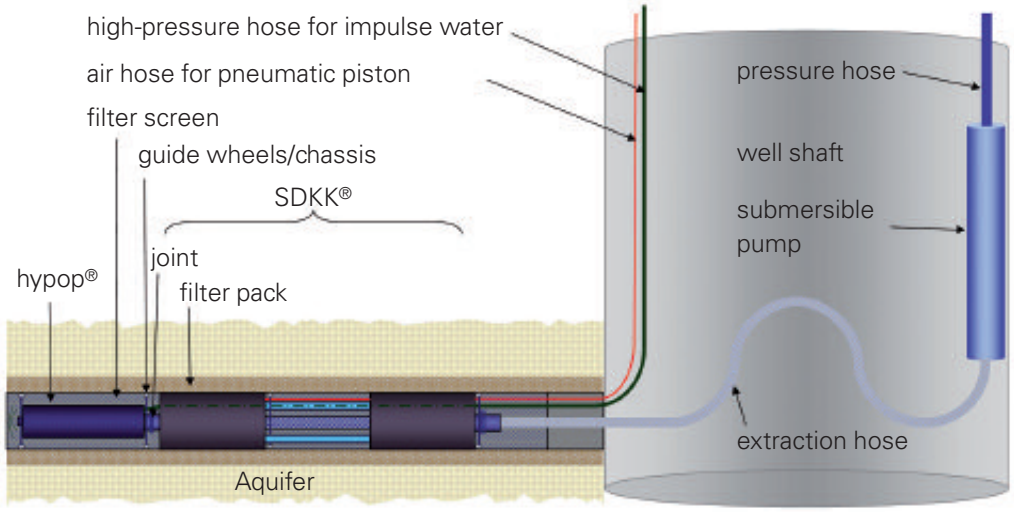

Fig. 3: Implementation of the HPD equipment with a flexible jointed axis and decoupled pump in a horizontal well

Source: Dr. P. Nillert

with water-driven impulse generators (hypop®) can generate adjustable pressures with impulses of up to 450 bar (6,500 psi) with a frequency of 2 Hz, respectively. Following successful field tests with prototypes **(Fig. 2a)** a compact version of the equipment was developed in which the hypop® technology is integrated in the extraction chamber **(Fig. 2b)**. With subsequent design improvements the limiting minimum well screen diameter for the equipment was reduced from DN 300 (12") to DN 175 (7"). Robust and fit-for-purpose tools for down-well deployment and field-proven high-performance high-pressure pumps by Uraca ensure reliable equipment performance on-site. The use of clean water as opposed to a gas (nitrogen or air) to generate pressure impulses has a significant advantage in that the impulse is limited to the mechanical pulse transmitted via the water in the well over the screen and filter pack to the surrounding sediment.

Like other impulse technologies, the application of hypop® increases the compaction of the filter material. Hence this system is also used on its own without the intensive extraction chamber for compaction of the filter pack during well construction.

The greatest challenge in well de-sanding is the treatment of horizontal well screens, as the work in the water-filled well shafts generally has to be carried out by divers working under very difficult conditions. The transfer of the HPD technology from vertical to horizontal screened wells is not straightforward, as the several meters long tool string consisting of double packer chamber with impulse generator and submersible pump is heavy and unwieldy, and thus difficult to move with any degree of accuracy in a horizontal screen. This is compounded by the fact that horizon-

Fig. 4: HPD equipment hypop®, SDKK®-300.600 and submersible pump for the development of a horizontal well for the municipal utilities Weinfelden AG in Schachen, Switzerland

Source: Tefotec® GmbH

tal well screens are not always straight and often have bends along the screen axis.

On the basis of long experience in the maintenance of horizontal wells, Teftorec® GmbH has successfully developed a technical solution to this problem **(Fig. 3)**, making the use of HPD in horizontal wells both economically and technically feasible. By replacing the submersible pump with a special suction pump in the well shaft, the resulting tool string is both shorter and lighter. The flexible hose between the pump and the extraction chamber can easily be assembled on-site from short hose sections as required. The double packer chamber is adapted for use in horizontal screens by replacing the rigid linkage between the packers with a flexible joint. This enables the tool to move through difficult screen sections whilst maintaining full contact between the packers and the well screen **(Fig. 4)**. As the well screen is treated working inwards from the end of the screen to the well shaft, by using a suitable winch mechanism the actual filter treatment, once started, can be completed without further help from the diver, reducing both risks and costs.

Similarly to HPD in vertical wells, the deployment in horizontal wells follows a detailed plan, which is developed based on the well construction data. In the field the flow rates, mass removal rates, impulse frequency and pressure are continually monitored, documented and checked against the specifications set forth in the deployment plan. The careful monitoring and competent assessments by experienced personnel on-site ensure that technically optimal results are achieved whilst keeping operational times and thus cost to a minimum.

Eleven horizontal wells have been successfully treated with HPD to date, including wells belonging to the Berliner Wasserbetriebe, the Lower-Rhein Dewatering Association (LINEG) and the City of Mainz that have been in operation for more than 50 years. A new well constructed by BHG Brechtel GmbH for the municipal utilities Weinfelden AG (Switzerland) consisting of 15 screens in four levels over 30 vertical meters (98 ft.) was developed using HPD. Exceptional well yields and water quality were achieved in this case by optimizing the filter pack and screen slot size for HPD during the design of the well, which was constructed using the PREUSSAG method.

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Footnote

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