High Pressure Impulse-Process® with high water pressure as a method for efficient well development

A newly drilled well is not yet ready for operation as it still needs to be developed and sand needs to be removed. In Germany, this work is carried out by specialist drilling companies that are certified according to DVGW W 119.

A number of development methods, such as swabbing and surge plugging, but also jetting processes no longer correspond with the state of the art, based on interim investigations and practical knowledge. One reason for this is that too little attention is paid to the physical background. These and other findings will now be examined in more detail.

Why is it important to remove sand and develop a well? Unfortunately, well drillers and the construction management partly still think today that a well is completely developed after the swabbing, airlifting and surge plugging. Whether this work was done correctly and the well has already reached its full capacity is unfortunately rarely questioned. What kind of deposits should finally be removed during the development process must first be determined.

Relations

The following photos (1 and 2) should illustrate the relations. It was monitored, that various wells showed widely differing capacities and drawdown characteristics, despite the fact that they were placed in a row in the same geological formation. Such wells were drilled with air lifting technology including the use of bentonite.
In order to gain an insight view into the cross-section of two wells, careful attention was paid to the filter area during their dismantling.

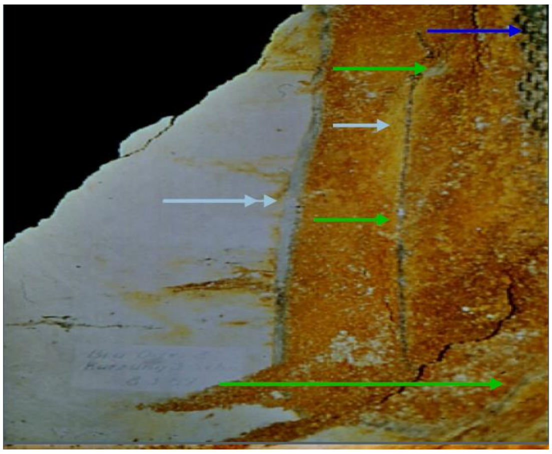

Fig.1 shows double gravel pack

Fig. 2: filter cake is completely existent allowing less water passage

- The blue arrow points the filter screen
- Two filter cakes occur (white arrows)
- Filter cake couldn´t be destroyed by swabbing → most areas were clogged (only in region of the green arrows allowed water to pass)

- Filter cake grows more strongly on the borehole wall than on the inner one (between the two fillings) due to the longer formation time.

A well which was drilled with airlifting can´t be fully developed with swabbing, shock pumping and/or surge plugging. Even with the most modern methods, both filter cakes cannot even be removed completely, if one does not want to run the risk of mixing up the two gravel packs completely. The well was developed in such a way that it could not even start with its maximum well performance.

Flushing applied correctly would reduce the filter cake to fractions of a millimeter. Furthermore, the filter cake wouldn´t grow with increasing drilling time and would be easily removable due to its water-permeable components. In opposite to the ETSCHEL JET Master®, which can remove the entire filter cake, swabbing and surge plugging can only remove 40-60% of it. This fact was proved, when the JET Master® was redeveloping old deep wells which after treatment with the HPI-Process® showed way better specific yields.

Fluid mechanics fundamentals

Sheet W55/99 published by the recognized standardization body for the gas and water industry in Germany (DVGW) already attested the High Pressure Impulse-Process® a "remarkable sand removal effect" in 2003. Also, the treatment area into the gravel ring space was graphically displayed (Fig. 3).

The HPI-Process® with high water pressure is generating pressure impulses which are able to treat the whole gravel pack all the way through to the borehole wall and even beyond into the aquifer. This areal treatment is only possible with units equipped with 4 nozzles on 2 plains. The double rotation units are displacing the water horizon into the gravel ring space by generating negative pressure. This negative pressure is the reason for the remarkable sand removal effect. If the unit would work only in one plain, the vertical area treated would only be about 25cm. However, numerical calculations have shown that a vertical treatment of 40 cm to 60 cm in the gravel ring space can be achieved when using a bi-rotational unit working in two plains. The better depth effectiveness is achieved on the one hand by the continuous up and down movement of the unit. On the other hand, the flexible adaptation of the unit to the well construction plays an important role. Nozzle distance, speed, pressure and other parameters can be adjusted according to the construction of the well. In opposite to conventional developing methods, way better developing effects can be achieved by applying the HPI-Process®.

Fig. 3 shows, how the double rotation unit is generating negative pressure (red square) which is displacing the water horizon (blue lines) into the gravel ring space (on the right site of the red square). This effect can only be achieved with an aggregate with 4 nozzles working on 2 plains, which can be flexible adjusted according to the construction of the well.

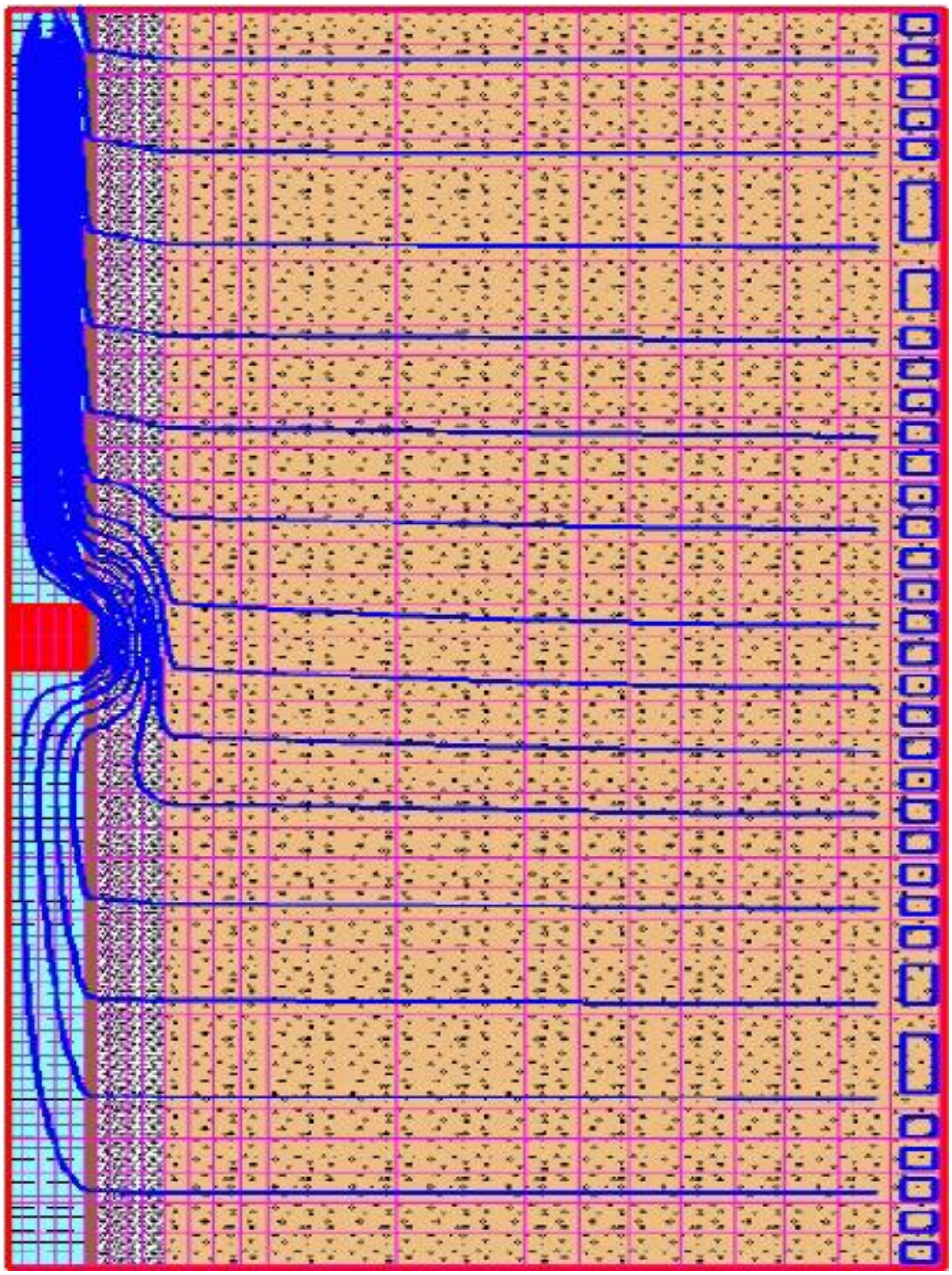

Fig. 3 DVGW W 55/99

Three well developments in practice

Test 1: July 2008, south Germany

Well data:

- Year of construction 1971 (well was never in operation)
- drilling diameter 572/521mm, drilling depth 38m (114ft.)
- well depth 35,6m (107ft.)
- dimensions
  lock casing DN 500 (20")
  casing DN 350 (14") / 18,6m (56ft.) Rilsan coated
  filter screen DN 350 (14") / 13m (39ft.), Diameter 359mm Bridge slotted Rilsan coated
  bottom casing DN 350 (14") / 4m (12ft.) Rilsan coated
- filter gravel: 3-7mm
- static water level: -28m (54ft.)

Pumping test data of 1971 (after development with shocking, swabbing and surge plugging):

Pumping time with 28,5 l/s = 66hrs (total pumping time: 232 hrs)

Date	**Time**	**Draw down (in m)**	**Draw down (in ft.)**	**Flow (l/s)**
05.07.1971	3:00 pm	28	84	0
05.07.1971	4:01 pm	29	87	20,3
06.07.1971	6:00 pm	29,18	87,5	20,3
07.07.1971	7:00 pm	32,5	97,5	28,5
08.07.1971	7:00 pm	33,2	99,6	28,5
09.07.1971	7:00 pm	33,3	99,9	28,5
	1:00 pm	33,3	99,9	28,5

Specific yield: 28,5 l/s / 5,3m (15,9ft.) = 5,4 l/s/m draw down (1,79 l/s/ft. draw down)

Pumping test data of 2008 (after development with HPI-Process® with high water pressure – system JET Master®):

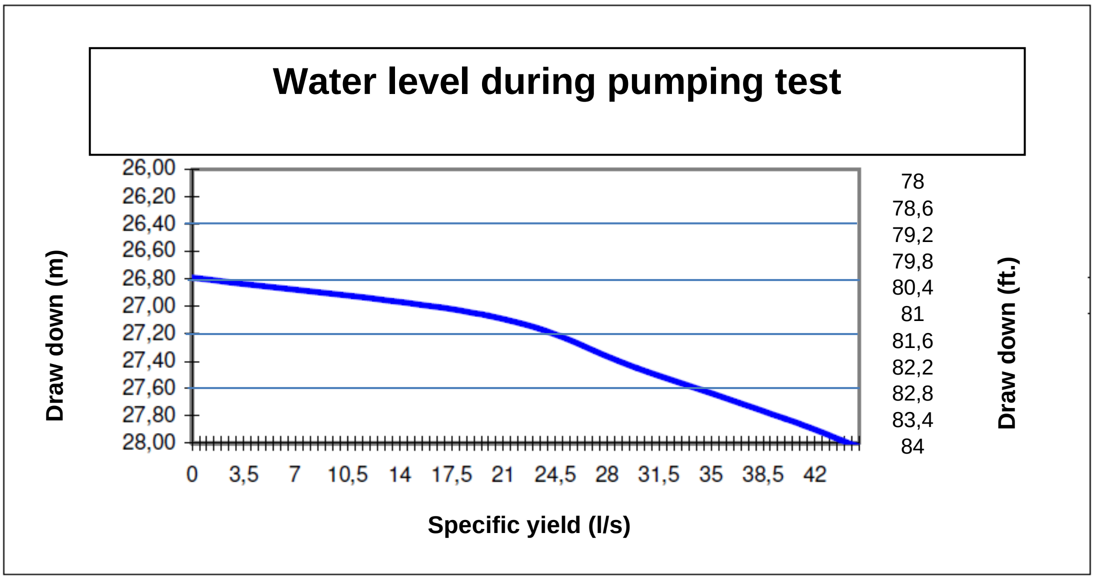

Fig. 4: Pumping test data after JET Master development

Date	Time	Draw down (m)	Draw down (ft.)	Flow (l/s)
01.07.2008	7:00 pm	0		0
01.07.2008	7:01 pm	26,79	80,37	20,1
01.07.2008	8:00 pm	26,98	80,94	20,1
02.07.2008	6:00 am	27,05	81,15	20,0
02.07.2008	6:01 am	27,07	81,21	30,2
02.07.2008	6:02 am	27,35	82,05	30,1
02.07.2008	7:00 am	27,37	82,11	30,1
02.07.2008	6:00 pm	27,51	82,53	30,1
02.07.2008	6:01 pm	27,45	82,35	40,1
02.07.2008	7:00 pm	27,70	83,1	40,1
02.07.2008	9:00 pm	27,79	83,37	40,1
03.07.2008	8:00 am	27,81	83,43	45,0
03.07.2008	8:30 am	28,01	84,03	45,0
03.07.2008	9:00 am	28,02	84,06	45,0
03.07.2008	9:30 am	28,04	84,12	45,0
03.07.2008	10:00 am	28,04	84,12	45,0
03.07.2008	11:00 am	28,03	84,09	45,0
03.07.2008	12:00 am	28,03	84,09	45,0

03.07.2008	1:00 pm	28,03	84,09	45,0
03.07.2008	2:00 pm	28,03	84,09	45,0
03.07.2008	3:00 pm	28,03	84,09	45,0
03.07.2008	4:00 pm	28,03	84,09	45,0
03.07.2008	5:00 pm	28,03	84,09	45,0
03.07.2008	5:01 pm	27,02	81,06	0
Measurement	**of rising**	**water level**		
03.07.2008	5:02 pm	26,98	80,94	0
03.07.2008	6:00 pm	26,82	80,46	0
03.07.2008	6:10 pm	26,81	80,43	0
03.07.2008	6:20 pm	26,81	80,43	0
03.07.2008	6:30 pm	26,80	80,4	0
03.07.2008	6:40 pm	26,79	80,37	0
03.07.2008	6:50 pm	26,79	80,37	0

Specific yield: 45 l/s / 1,25m (3,75ft.) = 36 l/s/m draw down (12 l/s/ft. draw down)

→ **6,7x increase of the well performance**

This well was drilled using grab drilling method with auxiliary casing. While drilling a 2 m (6ft) section of tone and clay was drilled through in the upper section. This resulted that tone and clay deposits were transported by the auxiliary casing to the lower sections of the well along the borehole wall. The initial well development with shock pumping, swabbing and surge plugging could not remove such water-resistent deposits. Only the use of the HPI-Process® could remove these natural deposits and develop the well properly which has led to an enormous increase of the specific capacity.

Test 2a: September 2008 – KIWA water research, Netherlands

Well data:

- Year of construction 2008 Rotary Drilling with Xanthaan
- drilling diameter 450mm, drilling depth 19m (57ft.) in fine sand aquifer
- well depth 19m (57ft.)
- dimensions
  Casing DN 300 V2A (12”) / 12m (36ft.)
  Johnson type filter screen DN 300 V2A (12”) / 6m (18ft.), Slot size 0,3mm
  Bottom casing DN 300 V2A (12“) / 1m (3ft.)
- filter gravel: no gravel

a) mechanical development with HPI-Process® with high water pressure (system JET Master®)
b) additional, chemical development with 1.272 liter 7% hydrogen peroxide, 24hrs

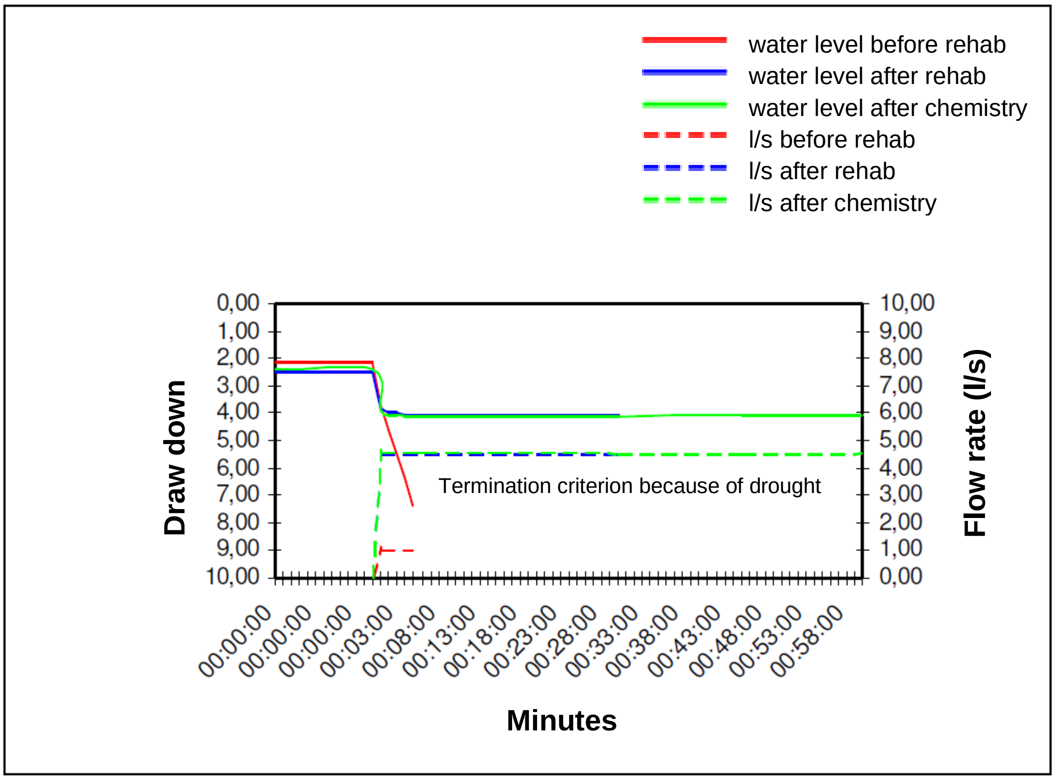

Fig. 5: Pumping test data after JET Master development

The well was completely developed with the JET Master® until it was technically sand-free and all Xanthaan was removed. The subsequent chemical development did not lead to any improvement in performance and no more Xanthaan components were extracted. The pumped quantity of 4.5 l/s corresponded exactly to the well's performance planned in advance.

Impressions:

Fig. 6: well development with JET Master

Fig. 7: HPI-Process with high water pressure and simultaneous pumping

Fig. 8: measurement tool with sample extraction

Fig. 9: separation container

Fig. 10: Chemical treatment with 7% hydrogen peroxide

Both tests, 2a and 2b were carried out to evaluate the development-capability of a 300m (900ft.) deep horizontal well with the JET Master® in the same aquifer.

Test 2b: September 2008 – KIWA research

Container with simulated well

Data:

- depth 2,5m (7,5ft.)
- dimensions
- DN 300DN PVC (12") vertical slotted, and DN 300 (12") Johnson Type without gravel
- filter screen length 1m (3ft.) / Slot size 0,3mm
- Filling with sand according to the local mountain range
- Pumping off via an elbow at the lower end of the filter section connected to equally dimensioned full screen DN 300
- Plexiglas panel fitted with a lateral seal

Fig. 11: test container

Fig. 12: Johnson filter screen is coated with sand

Fig. 13: The Johnson filter DN 300 is treated with JET Master

Fig. 14: an observation platform is installed

Fig. 15: filled test container with suction device to simulate simultaneous pumping

Fig. 16: Measurement of the sand configuration after excavation and JET Master® development

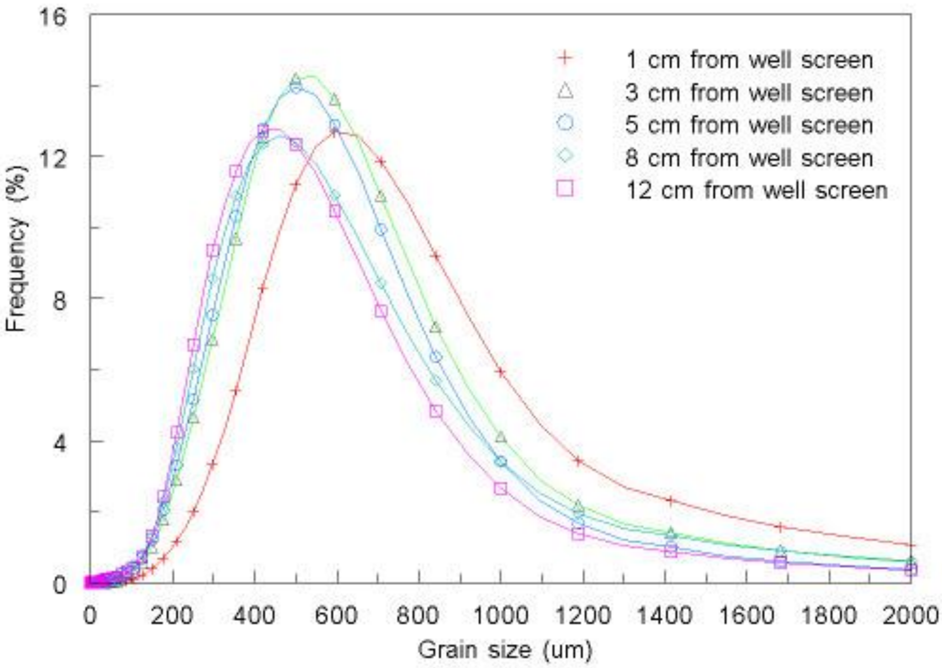

Fig. 17: Evaluation of the sand configuration after JET Master® development by sieve analysis

Conclusion:

The simulated well in the container (Fig. 11-15) was completely developed with the ETSCHEL JET Master®. The sand particle size was measured on 5 different distances to the filter screen wall (Fig. 17). Larger particle sizes were arranged symmetrically around the filter screen (Fig. 16). The fine sand parts were completely removed until a distance of 12cm behind the filter screen. From a distance of 12 cm to the filter screen the sand configuration corresponds again to the natural aquifer.

Concluding remark:

Many drilling companies don´t have comparable technologies or experience in the correct application of the HPI-Process®. Just a rotating nozzle system (standard jetting methods) is far away from the effectiveness compared to applying the High Pressure Impulse-Process®.

Many thanks to KIWA Water Research, Netherlands and Brabant Water Supply Company, Netherlands

Annex

Amongst other publications this article has let to working out an updated version of the „technical regulation W119“ for well development by the DVGW.