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Effect of Suction Flow Control Devices in Wells

By G. Ehrhardt and R. Pelzer

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Dipl.-Ing. Rudolf Pelzer, born 1937, study machine construction - processing engineering at the Technical Highschool Aachen, Germany; 1964 - 1981 worked as R & D engineer in following German Companies : Dynamit Nobel, Troisdorf; Krantz, Aachen; Vereinigte Glaswerke, Herzogenrath; Klöckner-Humboldt-Deutz, Cologne; since 1981 development manager for the plastic pipe division of Kabelwerk Eupen AG / Câblerie d'Eupen S.A., Belgium.

General introduction by Stuart A. Smith, CGWP, Consulting Hydrogeologist, Ada, Ohio, USA.

The following paper is an English translation of a German-language publication that provides theory and case histories for an important "new" concept in well design and well restoration planning, the suction flow control device (SFCD). An SFCD (in its current form) is a kind of variably slotted or hole-perforated pumping tailpipe extending to the bottom of a well screen or intake area. The result is to force nearly completely cylindrical flow into the well from the aquifer. In wells without SFCD, flow in most cases occurs predominantly near the top of the screen, with flow volume and velocity diminishing downward. Nearly 100 % of the influx may occur over the top 5-15 % of the screen area, with the rest of the screen essentially not working.

The word "new" with respect to SFCD theory is used advisedly because the concept behind SFCD operation is not new, having been described in work dating back a number of years. The uneven screen flow condition was observed experimentally as early as the 1950s in Germany. What is new is application in solving routine operational well problems.

Work has proceeded independently in the USA using a modified SFCD-principal device, as well as in Europe (as described herein). USA installations have shown results similar to those described in the case histories presented here: reduced or eliminated sand-pumping and elimination of turbidity of pumped water.

The SFCD concept described here has been slow to be accepted because it seems to discredit some fundamental principals of screen hydraulics such as presented in standard industry publications. Standard screen hydraulics (e.g., Mogg, 1972) assume an ideal cylindrical influx to wells. This flow concept does not account for lower pressure inside at the top of the screen and, consequently, (1) vertical flow components through long parts of the gravel pack and (2) higher inflow velocities at the upper part of the screen. The theoretical work, laboratory tests, and well installations described herein back the SFCD theory proposed by the authors. Similar theoretical work has been published in English-language (USA) literature.

The effect proposed on iron-biofouling incrustation problems (slowing and dispersing the clogging effect) is particularly compelling to me, because (1) this is a special interest of mine and (2) plugging in upper screen zones (presumed high velocity) has been repeatedly observed in well restoration work. Iron biofouling clogging of screens and pumps, and associated corrosion, are collectively the number 1 cause of performance loss in wells of all types worldwide. If SFCD can indeed help to buy time until rehabilitation becomes necessary, this is indeed exciting.

I encourage you as a professional hydrogeologist specializing in well performance to take this work seriously and to embrace the SFCD concept in your well designing and planning. The authors and I will be glad to explore any concepts further. For further reading on SFCD applications, I suggest:

Borch, M.A., S.A. Smith, and L. Noble. 1992. Evaluation, Maintenance, and Restoration of Water Supply wells. AWWA Research foundation, Denver, CO.

Nuzman, C.E. 1989. Well hydraulic flow concept. in: Recent advances in Groundwater Hydrology. American Institute of Hydrology, Minneapolis, MN.

Nuzman, C.E., and R.C. Jackson. 1990. Aquastream Suction Flow Control Device. in: Proc. Conserv 90, August 12-16, 1990, Phoenix, AZ, National Water Well Assn., Dublin, OH.

Pelzer, R., and S.A. Smith. 1990. Eucastream Suction Flow Control Device: An Element for Optimization of Flow Conditions in Wells. in: Water Wells Monitoring, Maintenance, and Rehabilitation, E.& F.N. Spon, London.

Stuart Smith, CGWP, is coauthor of Evaluation, Maintenance, and Restoration of Water Supply Wells published by the American Water Works Association, Manual of Hydraulic Fracturing for Well Stimulation and Geologic Studies (National Ground Water Association) and numerous other publications relating to well maintenance and rehabilitation. He is a USA technical consultant to Kabelwerk Eupen AG, marketer of the Eucastream (SFCD II) concept).

Effect of Suction Flow Control Devices (SFCD) in Wells

Summary

In the following article the representations in bbr 12/89 - mathematical treatment of flow conditions in unrealistic wells, s. [1,2] - are completed. Wells with and without SFCD and the hydrotechnical development of the SFCD of the so-called second generation are described and com-

pared in this paper. The successful application of SFCD is demonstrated by selected case histories from the presently considerable store of experiences in Europe. Among these are an almost 100 % reduction of sand concentration and of water turbidity in the pumped water previously caused by small and ultra-fine particles. These experiences demonstrate that SFCD of the second generation reduce local excessive velocities, i.e. they equalize the inflow to a high degree along the screen length, without filtering. It is therefore advisable to install SFCD in wells with imminent sand pumping before the first pump test. Normally the flow within the aquifer is not influenced by the SFCD with the exception of aquifers consisting of gravel with large free spaces and incorporations of sand, as they exist in Spain, for instance: in these aquifers, too, the equalizing effect of the SFCD can prove very useful.

1. Introduction

The free surface of screens (slot area) in wells is in most cases so large that its pressure loss can be ignored. There remain, however, two pressure differences, h and H, which are basic parameters for the analysis of flow conditions in wells without SFCD. They can easily be estimated on the initially idealizing assumption that the flow through the gravel pack is completely radial. The pressure loss h of the gravel pack depends on its thickness and the grain size. The axially directed pressure drop H within the screen depends on its length and diameter. The ratio H/h thus found can serve as first criterion for the amount of the vertical component of flow velocity coming up in the gravel pack.

The technical data of the well described in [1] and [2] lead to a ratio H/h in the order of 1, a relatively small value, which does not allow the arising of appreciable vertical components. The numerical solution [1] supplies nearly vertically running equipotential lines in the gravel pack. As the vector of flow velocity is vertical to these lines, it follows that the flow through the gravel pack is nearly radial. In this case the installation of an SFCD is unnecessary.

The technical data of the well described in [3], however, lead to a H/h in the order of 100, and this really great value causes considerable vertical components in the gravel pack according to the estimation in [3]. In this case the installation of an SFCD is advisable.

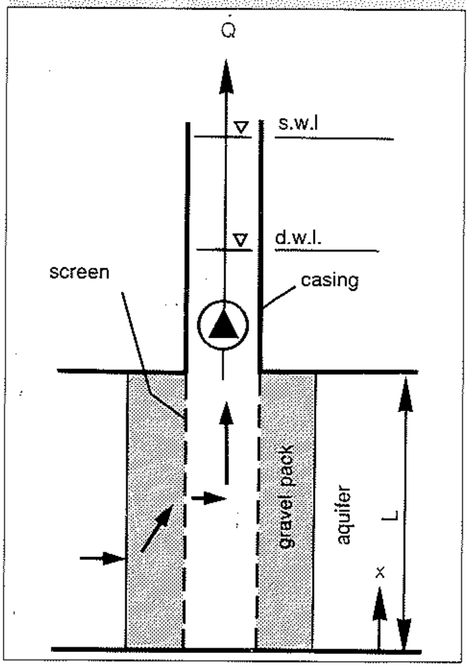
In the paper in hand the flow conditions in wells with and without SFCD are qualitatively described, the methods of designing the SFCD-Eucastream are explained and at last practical experiences with these SFCD are reported on.

2. Flow Conditions in Wells

Simplifying the following reflections a homogeneous confined aquifer is assumed, limited at the top and at the bottom by impermeable formation layers. Furthermore the height of the homogeneous gravel pack and the length L of the uniformly perforated screen are supposed to be identical with the thickness resp. height of the aquifer, and the pump is supposed to be positioned in the casing (cp. fig. 1 and 2).

2.1 Without SFCD, Fig. 1

1 Well without SFCD



The increase of impulse and the friction force in the screen effect a pressure drop in x-direction. As a result, the radial pressure difference moving the volume elements of the water from the wall of the borehole through the gravel pack and the perforation of the screen jacket increases from bottom (x=o) to top (x=L). In consequence the highest flow velocities take place near the top of the screen. Though all the volume elements normally leave the aquifer with identical velocity, their flow velocity through the perforation of the screen is much greater at the top than at the bottom. This variable suction or collecting behaviour of the screen, also mentioned by G. Krems [4], inevitably leads to a vertical flow component in the gravel pack, which can easily be demonstrated by means of the equation of continuity (3) which is cited subsequently.

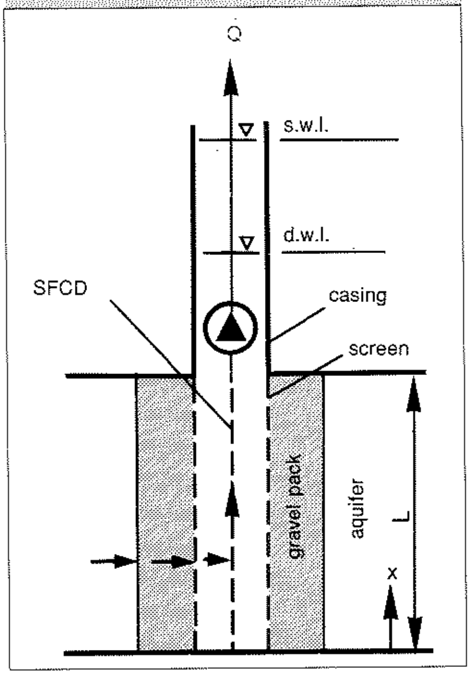
According to the assumption in fig. 1 the vertical flow component is zero at the positions x = 0 and x = L, and according to [3] it has a maximum at the position x = (0,5 to 0,6) x L. Data which are more exact in quantity than the estimation [3] can be found by the numerical solution of the differential equations of flow [1].

According to [3] in case of great values of the above mentioned ratio H/h, the vertical flow component is considerably greater than the horizontally directed velocity of the water leaving the aquifer. This is undesirable because a great vertical flow component is regarded as the reason for sand-conveying from the wall of the borehole. The concept of sand-conveyance due to high vertical velocity is backed up by the comments of C. Truelsen [5]. He explains sand-conveying of wells by "unequal" or "non-uniform" flow conditions when he writes: "Unfortunately the surface of a well-screen is by no means uniformly loaded by inflowing water. In case the entry of the suction pipe is positioned above the screen, the upper part of the screen is significantly stronger loaded than the lower part; the conditions are opposite, however, if the suction pipe ends up in the sump of the screen. A uniform entrance of water throughout the total length of the screen could be obtained by a suction pipe of identical length within the screen with a perforation adapted to the flow rate on the total screen length ... (quotation subsequently continued).

O. Kirschmer [9] investigated flow of water pumped through screens with a gravel pack coating which collect water from a big water basin. He used a DN 200-screen (I.D.: 200 mm) with 9 % free surface, which had a 80 mm-thick gravel pack coating with grain sizes of 2 to 3 mm. He found out that the influx of water is concentrated in the upper part of the screen. In the lower part there was no influx to be observed. In spite of the relatively thick gravel jacket of fine grains, the entrance of this screen by inflowing water thus was extremely unequal (non-uniform). Due to the assumed condition of a "big water basin" the results of these investigations, however, may only be transferred to wells in extremely permeable aquifers, e.g. coarse gravels with large interstitial solid-free spaces between the grains.

2.2 With SFCD, Fig. 2

2 Well with SFCD



In a well equipped with an SFCD, all the volume elements of water sucked in move from the wall of the borehole through thegravel pack and the slots of the screen on horizontal paths, and they are turned round into vertical direction not before reaching the interior of the SFCD. Thus a vertical flow component in the gravel pack does not exist. This flow pattern basically differing from that in a well without SFCD is achieved owing to the fact that the SFCD sucks off the same partial flow rate $\Delta\dot{Q}$ over each section Δx of the area $0 < x < L$. Even these proceedings effect an increase of impulse and friction forces, which, however, remain restricted to the interior of the SFCD, neither affecting the annular space between SFCD and screen nor the gravel pack. These statements are basing on SFCD designed according to the "Eucastream"-principle.

3. Suction Flow Control Device

From the physical point of view there are two principles leading to a uniform distribution of $\Delta\dot{Q}$ over L: On the one hand the principle of great flow resistance and on the other hand the principle of adjusted free surfaces (perforation). According to these principles the SFCD of the first [6] and the second [7] generation are designed.

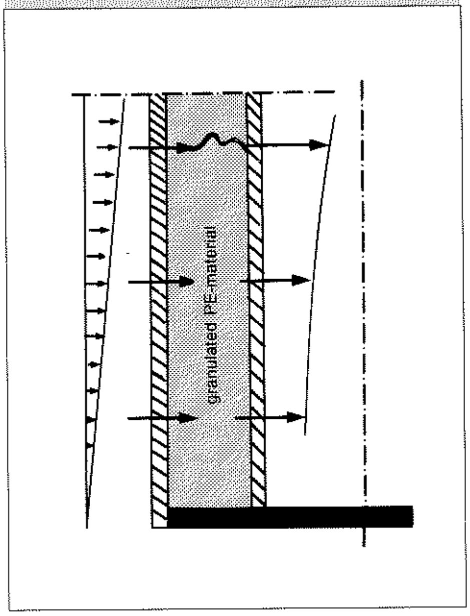
The principle of adjusted free surfaces is mentioned by C. Truelsen [5] "... a perforation adapted to the flow rate on the total screen length and which adequately increases in number or diameter of the holes from top to bottom. But as these requirements are hardly to be realized, it would be better to take as a basis for the well design a smaller inflow velocity than the maximum permissible. So no sand will be rinsed into the well even in cases of slightly increased flow rate."

Truelsen's doubts about a possible realization of these ideas probably were the reason for firstly constructing SFCD not earlier than in the late 1970s and secondly chosing the a.m. principle of great resistance at first (first generation). In the middle of the 1980s the development was continued by applying the principle of adjusted free surfaces (second generation).

3.1 First generation (SFCD I), Fig. 3

SFCD of this type consist of two concentric thick-walled pipes of different diameters, closed at the bottom, with uniformly slotted jackets and a filling of plastic granulate in the annular space. This construction is similar to conventional pre-pack screens only at a glance: The differences consist in the use of (1) granulated polyethylene material strongly compacted and (2), which is much more important, of slightly slotted PVC-pipes (small relative free surface, only 1-2 %, principle of high flow resistance). Equal

3 SFCD of the first generation

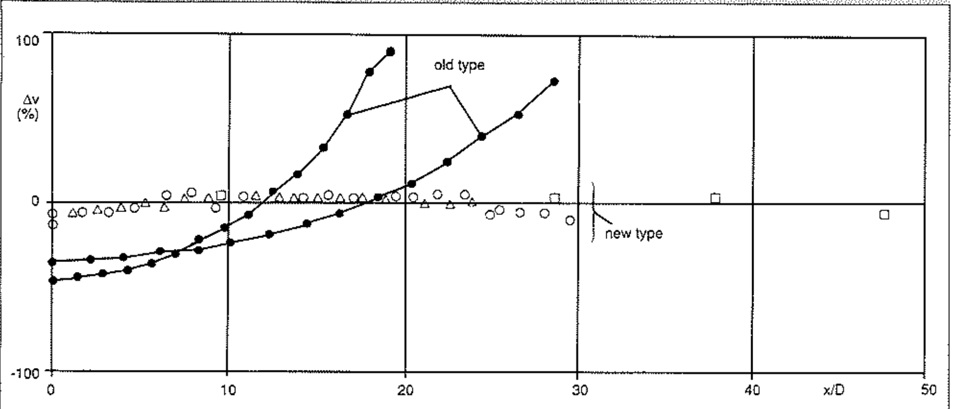


suction over the length of this SFCD can only take place if the free surfaces (slot area) become infinitesimal and/or the coefficient of resistance in the granulate filling tends to infinity. Both requirements are technically unrealizable.

SFCD-constructions as a rough approach to the ideal design demonstrate the behaviour characterized by the curves "old type" shown in Fig. 4. Thus an equal suction does not occur, for the partial flow rate at the position x = 0 is too small by 50% and at the position x = L too high by 90%. Nevertheless these SFCD showed a partially satisfactory effect. Example: The initial sand pumping of the new well V in Weilheim, Germany, amounted to 20 cm^3 of sand per m^3 water (after desanding by pumping) and was reduced to virtually zero after the installation of an SFCD I in 1977. It clogged, however, after a working period of about 10 years at a flow rate of about 180 m^3/h and imploded. But without SFCD I about 80 l of sand per day would have been pumped and the well would have had to be put out of operation after a few days or weeks for danger of collapsing of the borehole.

The figures demonstrate that in spite of its unsatisfactory collecting behaviour this SFCD effects as a sufficiently uniform equalization of the inflow and thus had considerably diminished the transport of

4 **Deviation Δv from the zero-line in function of x/D for the SFCD I (old type) and SFCD II (new type)**



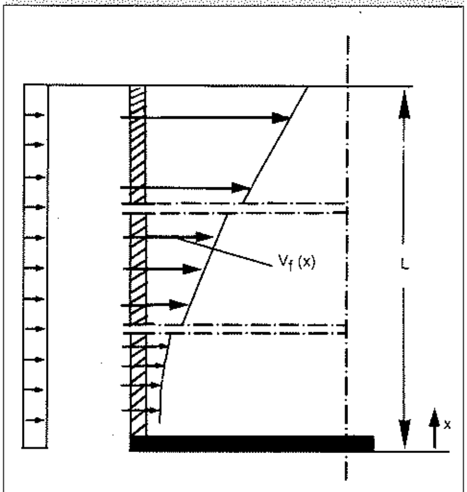
old type	: L/D = 19,2 and 28,6	L/D = 30 symbols ○	L : length of the SFCD
new type	: L/D = 25 symbols Δ	L/D = 48 symbols □	D : inner diameter of the SFCD

sand into the screen. Assuming that 80 l/day of sand, permanently conveyed out of the aquifer, would have been hold back by the SFCD I - as if by a filter -, it would have been clogged already after a few hours and not only after 10 years.

Despite of the considerably diminished sand pumping the following drawbacks of the SFCD I have to be pointed out: imperfect uniformity of distribution of the inflow, danger of clogging and consequently imploding, high pressure loss, relatively high purchase costs and a heavy weight due to the design.

3.2 Second Generation, Fig. 5

5 **SFCD of the second generation**

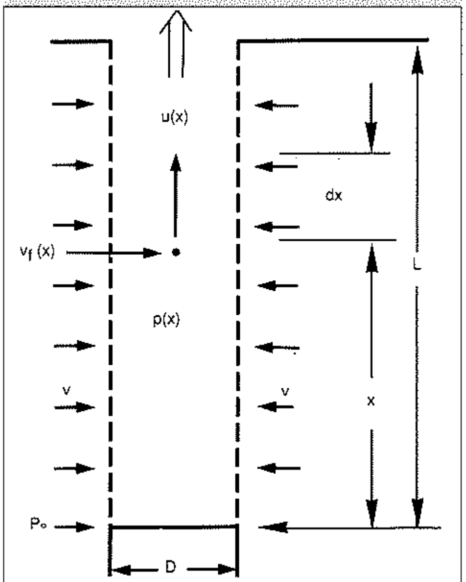


The SFCD of the second generation - SFCD II - consists of only one thin-walled pipe closed at the bottom, the relative free surface (perforation) ß(x) of which diminishes from bottom to top in the same degree as the velocity $v_f(x)$ in the cross sections of the free surfaces increases from bottom to top (cp. Fig. 5). Thus in each section Δx the flow rate

$$\Delta\dot{Q} = ß\,(x) \cdot v_f(x) \cdot \pi \cdot D \cdot x$$

is constant, i.e. independent of x. Consequently all the volume elements of water, in a certain radial distance to the SFCDII - pipe jacket, have the same velocity, independent of x and perpendicularly directed toward the jacket of the pipe. The relative free surface ß(x) can be found out with the help of the one-dimensional laws of conservation for incompressible flows. Using the terms defined in Fig. 6 you will get in differential notation :

6 **Explanation of symbols**



- □ the equation of continuity

$$d\dot{Q} = v\,D\,\pi\,dx = v_f\,ß\,D\,\pi\,dx = D^2\,\frac{\pi}{4}\,du, \quad (1)$$

- □ the theorem of momentum

$$dp + \rho\,g\,dx + \rho\,u\,du + \lambda\,\frac{dx}{D}\,\rho\,\frac{u^2}{2} = 0 \quad (2)$$

- □ and the law of conservation of energy

$$p_0 = p + \rho\,g\,x + \frac{1}{\varphi^2} \cdot \rho\,\frac{v_f^2}{2} \quad (3)$$

The relative free surface can be calculated by means of the equations (1) to (3) with the demand v = constant, and the equation for ß(x) contains as an empirical value the coefficient of friction λ within the SFCD II and the coefficient of velocity φ of the cross sections of the free surfaces (perforation). These values were estimated at first; tests with an SFCD II constructed according to these estimated values provided more exact values. After a further iteration the curve "new type" shown in fig. 4 was measured: The deviation Δv from the mean value (zero-line) is practically zero.

A subsequently developed computer program compensates the actually insignificant deviations Δv in fig. 4 by means of an empirical correcting function and allows the construction of SFCD II, which are individually adjusted to each well. The following advantages of the SFCD II are worth mentioning: clogging can be excluded; pressure loss is significantly diminished - in normal cases smaller than 0.1 m WC (WC : Water Column ≙ head) -; lower purchase price; lower weight; and most importantly nearly 100 % reduction of sand pumping due to practically completely uniform distribution of inflow on a low velocity level.

4. SFCD II - Experiences in Practice

First experiences were gained in 1977, to be precise, with an SFCD I (see paragr. 3.1) working on the principle of flow resistance. In spite of several further successes this principle was no longer applied, because danger of clogging could not be excluded in the long run. Since 1986 it was replaced by the principle of adjusted cross sections of perforation, realized with the SFCD II.

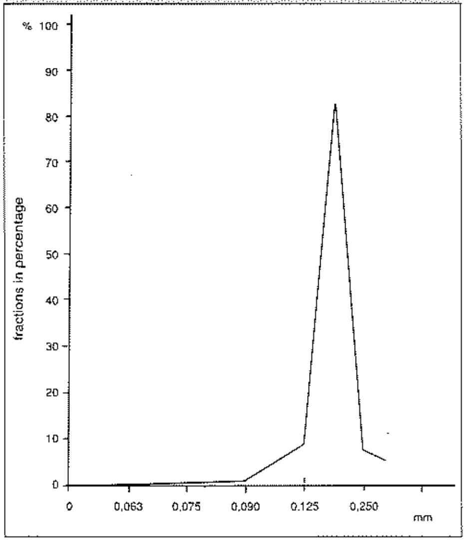
The data of some case histories of SFCD II - applications are collected in Table 1.

❶ Technical data and comparison "without / with" SFCD II

Well	Diameter (mm) Borehole	Screen	SFCD II	L m	$\dot{Q}$ m³/h	v_b mm/s	Results without SFCD II	with
Tilburg well 3	650	220	145	23,5[1]	120	0,64	c[2] = 20	c < 0,15
Weilheim well V	1200	600	500[3]	9,2	180	1,40	c = 20	c = 0
Sindel-Longenthal	800	300	200	78,5[4]	18	0,05	turbid at 18 m³/h	clear at 36 m³/h
Trendelburg	700	400	250	55,0[5]	80	0,22	turbid	clear

(1) SFCD II, 23 m long, s. Fig. 7
(2) Concentration cm³ sand/m³ water
(3) Pump and rising main inside SFCD II, s. Fig. 9
(4) SFCD II with 4 interspersed plain pipe intervals of 38 m total length, s. Fig. 10
(5) SFCD II with 1 interspersed plain pipe interval of 8 m length
v_b :velocity of the horizontally inflowing water at the wall of borehole
D_b : diameter of the borehole.

❽ Distribution of grain sizes of the pumped sand, well Tilburg (NL)



Objectives of installation have been:
- prevention of sand pumping
- avoidance of water turbidity
- retardation of incrustation due to bio-fouling.

In the following the corresponding results in some wells are described and explained.

4.1 Prevention of Sand Pumping

❼ Design of well n°23 in Tilburg (NL) with SFCD II

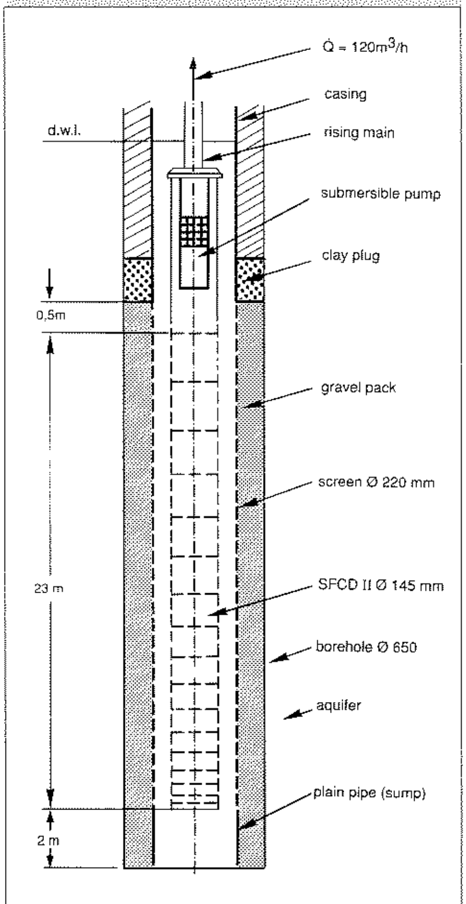


Fig. 7 shows the design of the well No. 23 in Tilburg, Netherlands, with an installed SFCD II. The aquifer in the area of the screen (length 23,5 m) essentially consists of sand interbedded with thin clayey layers. The gravel pack is closed at the top by a clay plug. The dynamic water level at nominal flow rate is located above the clay plug.

After nearly sand-free performance of several years the sand concentration in the pumped water suddenly increased to c = 20 cm³ of sand per m³ of water. This abrupt increase was supposed to have been caused by subsiding of the gravel pack into those areas where for years sand had been removed from the wall of the borehole. After the subsiding process, a gravel-free space developed beneath the clay plug, aggravating the non-uniform collecting behaviour of the screen. The upper sections were even more loaded by inflowing water than before the subsiding process.

Though there was not much hope for success, a 23 m-long SFCD II was installed as shown in fig. 7. Already two hours after pumping had been started, the sand concentration diminished to 0,5 cm³/m³ and after 40 hours it only amounted to 0,15 cm³/m³, which means less than 1 % of 20 cm³/m³, the concentration noted before the installation of the SFCD II.

This good result is surprising with view to the gravel-free space beneath the clay plug. In spite of the very unfavourable conditions the SFCD II must have reduced the flow peaks to a great extent. The sand particles still pumped are very fine; according to the distribution of grain sizes in Fig. 8, the greatest percentage of them has a diameter of 0,125 to 0,25 mm.

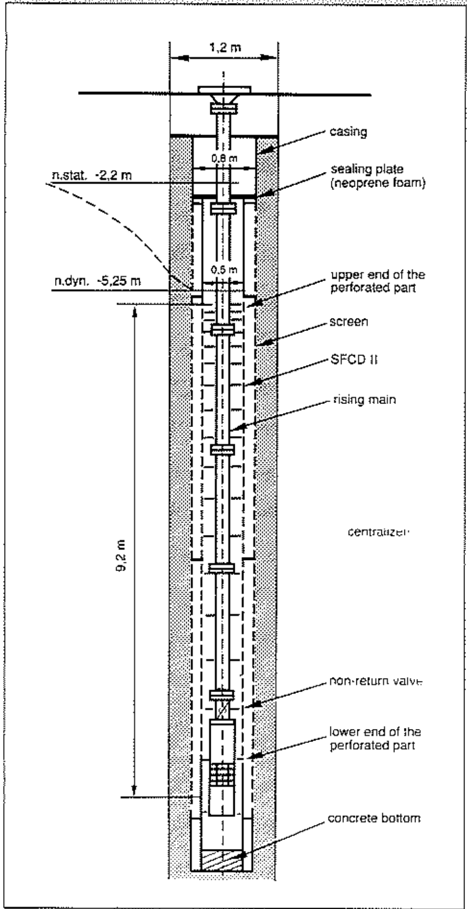
In this connection the wrong view is often taken that the SFCD II does not stop the sand erosion of the wall of the borehole, but that sand pumping is only prevented, because the sand conveyed into the well either sinks down into the sump or is filtered off by the SFCD. Both arguments are incorrect: Firstly the sump would be filled up with sand after a few hours, and secondly the SFCD II does not have any filtering effect. If it acted as a filter, it would be clogged before long. The above mentioned reduction of sand pumping of more than 99 % thus proves that even sand erosion from the wall of the borehole has practically been stopped. And this can only be managed by means of a fundamentally positive change of the flow conditions at the wall of the borehole due to the installation of an SFCD II.

Fig. 9 shows the design of the well V Weilheim equipped with an SFCD II. The pump and the rising main are positioned in the interior of the SFCD II. In this case the changed boundary conditions had to be taken into account in the calculating equations of paragraph 3.2 and the installed SFCD II calculated in this way, reduced sand pumping from 20 cm³ of sand per m³ of water to practically zero at steady operation.

4.2 Prevention of Water Turbidity

From the hydrodynamical point of view

9 **Well V of the municipal workshops of Weilheim (Bavaria - Germany)**



pumped turbid as well as sandy water are due to the same cause: particles are removed from the wall of the borehole in consequence of vertical flow components within the gravel pack, s. [3]. According to Table 1, in the well without SFCD II sand particles were removed from the wall of the borehole at exit velocities

$$v_b = \frac{\dot{Q}}{D_b \pi L} \quad (4)$$

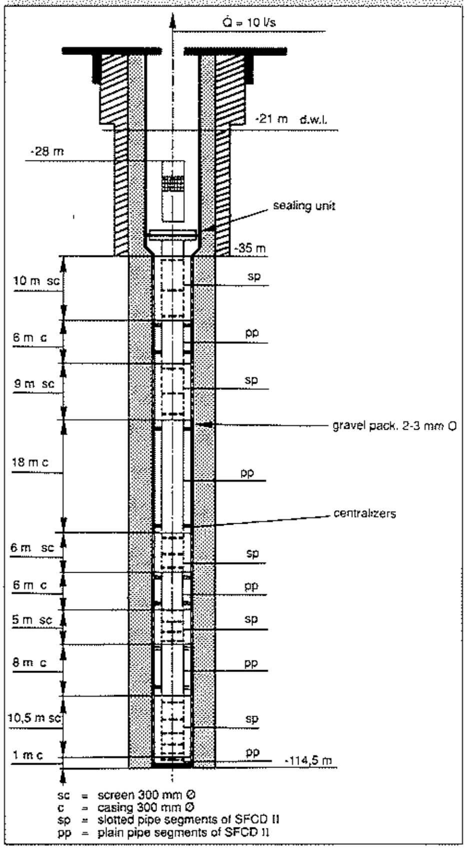
of the water leaving the aquifer between 0,64 and 1,4 mm/s, obviously because of greater vertical velocities along the wall of the borehole. The particles causing turbidity are definitely much finer than the aforementioned sand particles. Consequently even much lower exit velocities v_b = 0,05 resp. 0,22 mm/s (Table 1) lead to water turbidity. Fig. 10 shows the design of the well Sindel-Langenthal, Germany, equipped with an SFCD II. Over a total borehole length of 78,5 m five aquifers occur, separated by practically impermeable intermediate formation layers. In the area of the impermeable intermediate layers the screen is replaced by a casing. Corresponding to these circumstances the SFCD II is also perforated only in the areas of the five screen sections, between them there are intermediate pieces of solid pipes. For cases like this a special computer program was developed. Apart from the equations (1) to (3) it contains the known relation

$$dp + \rho\, g\, dx + \lambda \frac{dx}{D} \rho \frac{u^2}{2} = 0 \quad (5)$$

in which λ is the coefficient of friction depending on the Reynolds-number of the developed pipe flow in the intermediate pieces of solid pipes. After the installation of an SFCD II calculated in this way, clear water was pumped at a flow rate of $\dot{Q}$ = 36 m³/h. Before the installation, turbid water was pumped even at $\dot{Q}$ = 18 m³/h, that means an exit velocity of only v_b = 0,05 mm/s.

A likewise noteworthy result was gained in the well Trendelburg 3: Before the SFCD II was installed into the well, the water was made turbid by brown-red loam particles at a nominal flow rate of $\dot{Q}_N$ = 80 m³/h, after the installation, however, the pumped water was clear. These experiences confirm the positive effect of the SFCD II, equalizing the flow even under extremely difficult circumstances.

10 **Design of the well Sindel-Langenthal with SFCD II**



4.3 Retardation of Incrustation due to Biofouling

G. Krems [4] found out that incrustation of wells due to biofouling processes only occur in case of flowing water. Consequently these processes preferably take place in the upper areas of the gravel pack and the screen with the highest flow velocities, where the "iron-precipitating" bacteria are supplied with the greatest amount of food. After strong clogging of these upper areas by biofouling incrustations the inflow of water moves downwards, now causing incrustation and clogging there. This process is steadily continued until the whole well is clogged so far that further operation of the well is no longer possible. The drawdown of the dynamic water level is too strong and consequently the danger of dry operation of the pump too great. In this case an expensive mechanical/chemical rehabilitation of the well will be necessary.

The process of incrustation progressing from top to bottom can be influenced by the installation of an SFCD in such a way that clogging firstly will be uniform throughout all the sections of the well and secondly will proceed very slowly. Consequently the operating time of the well between two necessary rehabilitations is expected to be significantly increased. Corresponding experiments in this matter seem to back up these expectations. Reports will follow after the tests will have been finished.

5. Conclusions and Recommendations

As everybody knows the consequences of sand pumping are extremely serious: Sand-containing water has to be filtered in order to prevent sanding up of water mains and clogging of connected devices and equipment. Sand leads to wear of the pump, to progressive damage of the wall of the borehole, and finally to the failure of the well: Soon after the first caverns have developed, caused by sand-erosion of the wall of the borehole, the gravel will sag. Consequently gravel-free areas will grow in the annular space between screen and borehole wall, especially when the gravel pack is closed at the top by a clay plug. The inflow then prefers those areas and sand erosion of the wall of the borehole is increased, because support from the gravel pack begins to fail. Further collapses are the consequence and so on ad finitum.

The adequate data of the well V of Weilheim demonstrate this described process (s. Table 1): At $\dot{Q}$ = 180 m^3/h and c = 20 m^3 of sand per m^3 of water (without SFCD), pumped sand amounts to a quantity of 7,8 m^3 after three months and is just corresponding to the volume of the gravel pack. Neglect of the sand pumping have several times led to collapses perceptible even aboveground (e.g. sagged areas of a street).

If the pumped water still contains sand particles during the main pump test, there is no use hoping for improvement, from well reconstruction, but it would be better to install an SFCD II without hesitation. If gravel-free areas once have developed, increasing inflow within their range can eventually be diminished but not totally be equalized by means of the SFCD II. If sand pumping must be feared already during construction and development of the well, it should be equipped with an SFCD II even before the main pump test. Safety gained by this means will justify the 2 or 3 % increase of the total costs of well construction. The SFCD of the second generation are generally designed with a low hydraulic flow resistance, so that the sometimes feared throttling of the flow rate resulting from rescreening, as well-known, does not occur, and therefore it is out of all relation to the advantages "clear water" and "prevented sand pumping".

As a precondition for this statement, however, the perforation (slots, holes) of the SFCD II must be noticeably larger than the maximum grains of sand pumped before the SFCD-installation. The SFCD II of the well Tilburg 23, for example, has slots widths of 1 mm in comparison with the maximum grainsize of the pumped sand particles of 0,25 mm. The flow resistance of this SFCD II amounts to 1,1 m WC due to a relatively small screen diameter and certainly is unusually high (s. paragraph 3.2), but it is insignificant for the flow rate and the power consumption of the pump.

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