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CONSTRUCTION AND PRODUCTION FEATURES OF DEWATERING WELLS IN THE "KREKA" LIGNITE BASIN

by

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ABSTRACT

The paper presents information on constructional, technical and production features of dewatering wells in the "Kreka" lignite basin. A number of drilled wells (about 350), adjusted to suit actual hydrogeological conditions according to their function, construction and drilling method, were classified into several basic types.

INTRODUCTION

Coal mining in the "Kreka" coal basin is directly dependant on the degree dewatering aquifers, accompanying productive coal seams. Along with a long-lasting development of both underground and surface mining, the systems for previous dewatering have been developed as well, the basic components of which are hundreds of deep wells.

Complexity of montane-geological and hydro-geological conditions of the basin, along with different technical and technological factors, requested an optimal selection and adjustment of constructional features of wells in certain conditions, so different types of wells have been developed according to the following basic features:

- construction technology (methods of direct of reverse flushing),
- number of captures (single-degree or multi-degree wells),
- well depth and diameter,
- method of installed well construction (characteristics and diameters of casings, enforced construction, cementing etc.),
- kind and method of capture portion of a well processing (characteristics of filtering construction, widening in the interval of water-bearing layer, characteristics of filter stowing, mechanical, chemical and hydraulic processing of capture portions etc.).

In the drilling wells, we have done numerous test pumpings for the determination of filtering features of water-bearing layers and their spatial distribution, as well as for the determination of hydraulic features of wells and their exploitational parameters.

The basic hydraulic features of the wells are analysed as follows:

- o specific capacities and drawdown (Q/S relationship),
- o exploitation capacities of the wells in individual and group operation,
- o hydraulic resistance and well losses,
- o flow regimes in the pre-filtering zone (mechanical and chemical choking up, erosion, foundation failure etc.).

HYDROGEOLOGICAL CONDITIONS OF LIGNITE BASIN

The "Kreka" coalfield is a lignite basin of Pliocene age. It is only composed of loose and semi-loose type rocks, sands and clays with all intermediate forms and coal seams. Specific conditions of the basin formation have resulted in so-called "cyclic sedimentation, during which there have been formed 4 lignite seams: the lower, main, is upper and 2nd upper one, ie., locally, 5 coal seams with a sand layer in the floor and a clay layer in the roof This cyclic sedimentation occurs in the entire lignite basin with local vertical and lateral changes in lithologic characteristics, thickness and extent of a certain lithologic member of the sedimentation cycle. A typical lithologic column is given in Figure 1.

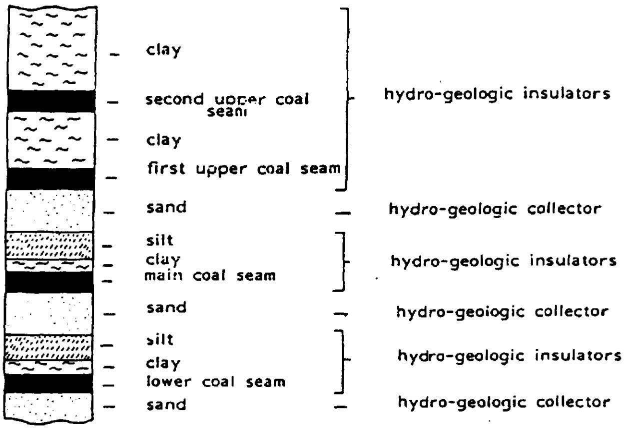


Figure 1. Lithological column of Kreka Lignite Basin

Structurally, the basin is a complex formation with a prominent folding tectonics and complete absence of radial tectonics (displacements). In general, there are synclinoriums (northern and southern) with a number of secondary forms (synclines and anticlines).

In such lithologic and structural conditions, there have been formed several aquifer horizons (ground waters) withstands - as hydro-geologic collectors and mutually separated lignite seams and clay layers as aquitards. The ground water is mostly of a sub-artesian type (under pressure) affecting a high hydrostatic pressure on the floor of the seam, being mined. With increase of mining depth, water content in aquifers has increased and become a limiting factor of coal production, due to water danger at the face, caused by uncontrolled water inrush as well as costly dewatering tecniques used.

The following significant aquifer horizons have been identified:

- o I Aquifer: sand in the bottom of the lower lignite seam:
- o II Aquifer: sand in the floor of the main lignite seam;
- o III Aquifer : sand in the floor of the is upper lignite seam.

The initial hydro-geologic regime in all strata is exclusively of a sub-artesian and syncline type with an additional water-accumulating in the aquifer by infiltration in higher zones of ground water and by drainage in lower zones of ground water.

With the advance of mining operations and dewatering system construction, the regime has bean significantly changed and prominent drainage zones have been formed in underground mines as well as open pits. In a 30-year period of an intensive mine development and dewatering, the ground water level has been lowered as much as 230 m.

WELLS IN A DEPOSIT DEWATERING SYSTEM

The underground and surface mines dewatering in the "Kreka" coal basin have been desired elsewhere. It may be noted that deep wells in the dewatering systems are basic components, along with other additional structures of active and passive dewatering.

Basic function of the dewatering system is being done through ground water withdrawal by means of wells, the number, arrangement and constructional and other features of which are adjusted to required results of ground water level drawdown in the mining area. A review of drilled wells with their basic features is given in Table 1.

WELLS CONSTRUCTIONAL CHARACTERISTICS

Drilling method and well constructional features are affected by a number of factors. The major ones are as follows:

- o number and mutual spatial relations among the aquifers to be drained,
- o technical features and capabilities of modern drilling equipment,
- o technical features and selection of standard casing and filtering equipment,
- o technical features and dimension standards of well equipment for water withdrawal as well as other factors.

Well Drilling Technology

Two major drilling technologies are being applied:

- o rotational drilling with direct flushing with bentonite drilling mud and water in the seam being captured,
- o rotational drilling with reversal flushing with water.

The first method is used for deeper wells and when geologic profile is mostly clayey and there is a possibility of clay swelling during the drilling. The basic drilling profile is 171/2" (444.5) with increasing up to 620 mm diameter in an interval of water-bearing layer being captured. By this method, the wells of the I, II, III-types are being drilled in the underground mines dewatering process.

Table 1. Drilling wells and their basic features

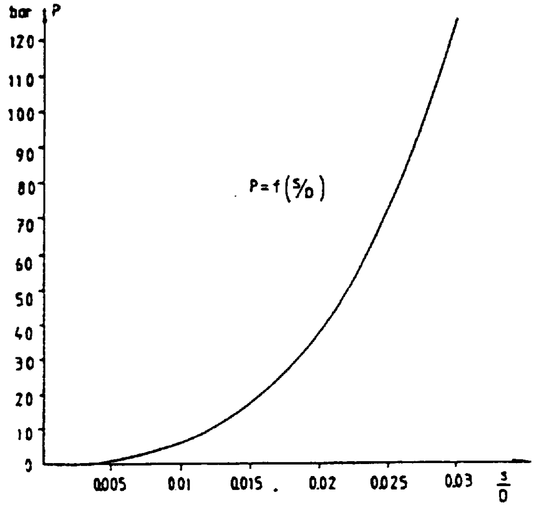
System of dewater (Area)	Number of wells in system	Type of wells	Captured water-bear layer	Capacity of wells l/s	Depth of wells m	Max lower m
Moluhe- I U.S.	6	I	III	2-17	370456	195
Moluhe - M.S.	2	I	II	7-12	326-370	221
	4	II	II	7-12	304-432	
Bukinje-I U.S.	20	I	III	2-27	265-602	
	1	II	III		357	
Bukinje M.S.	16	I	II	3-24	194-510	
	8	II	II	194-460		
Mramor-IU.S.	21	I	III	5-24	210-398	230
Dobrnja-IU.S.	27	I	III	3-18	248-481	175
Lukavac-M.S	13	I	II	5-20	119-420	150
	8	II	II	5-20	250-342	
	2	III	II, III	5	204-381	
	4	V	II, III	5-10	325-253	
	1	VI	II, III	10	234	
Lipnica-I-U.S.	16	I	III	10-20	309-443	230
Lipnica-M.S.	37	I	II	5-15	226-571	230
S.Brod	13	III	I,II	5-10	92-180	
	10	IV	II	2-10	43-120	50
	3	V	II,III	2-5	83-129	
Sikulji	40	IV	III	3-24	25-167	90
	4	I	II	16-22	232-272	
Dubrave	5	IV	III,II	1-3	84-174	220
	15	V	III,II	1-5	126-237	
	4	VI	III,II	1-7	213-264	
	1	IV	III	2	151	

The other method is more suitable and efficient for shallower wells in a mostly sandy environment. Basic drilling profiles is of 620 mm diameter and is being drilled continuously along the entire depth, with clean water flushing. The utilization of the bentonite drilling mud is exceptionally allowed, if the borehole is unstable. By this technology, mostly wells of IV, V and VI type are being drilled in an open pit dewatering process.

Construction of Well Casing

For well casing, there are used steel pipes with different diameters and wall thickness, depending on actual conditions in certain wells. In the beginning of well utilization for dewatering purposes, optimal pipe physical-mechanical features for expected critical loads on the structure (in-seam and hydrostatic pressures, dynamic strokes etc.) are analysed and, for a standard well construction, a pipe, with a diameter of 323.9 mm and pipe wall thickness of s = 7.1 mm is adopted.

With extreme well depths and possibilities of larger loads due to increased in-seam and hydrostatic pressures, pipe wall thickness is increased up to s= 10.0 mm. Other diameters are used depending on a need as an additional casing (conductor and protective casings) or intermediate casing (ove filter pipe, sump. etc.). With nonstandard casing, it is necessary to conduct checking of critical static pressure according to the relation given in Figure 2.



P = static pressure(bars), s = wall thickness (mm), D = casing diameter (mm)

Figure 2. Pressure testing of Non-standarded casings

Cementing and backfilling of Casing

For separation of various aquifers and, where it is necessary, for supporting the borehole wall, the annulus between the borehole and the casing is cemented in increments of 50 to 100 m. This involved use of a well-known "Perkin's method" of high pressure grouting by means of cement plugs utilising a drilling mud pump. The cementing is done for the I, II, III-type wells at intervals, before encountering an aquifer formation. The rest of the annulus is packed with fine-grained sand or other approppriate material.which decreases a possibility of borehole collapse during dewatering.

Filter Structure

The construction of the filter structure is the most important part of the well construction and therefore, special attention was paid to its installation. The collector section of the dewatering borehole consists of a perforated pipe with openings packed granulated filter so as to form layer of a single drainage unit. The objective of this is to enable a smooth flow of water from the aquifer to the borehole pump. In the course of time, experiments with different filtering materials have been carried out.For example, Nold-bridge type, metal-wire type, Johnson filters, filter with wire-net etc. For the standard use, an reinforced structure of a wound-up-wire-filter on perforated pipe has been used. Filter openings are usually ranging from 0:8 to 15 mm, and wire thickness is 3.4 mm and it is either Cr-Ni-Fe alloy or galvanized wire. Granulated filter packing is selected based on grain-size distribution features of detected water-bearing sand layer according to the following criteria:

D15/d15 = 8-2 [Morozov 1979],

ie. 4*d15 < = D15 < = 4*d85 [Terzaghi],

and filter openings, according to packing materials, in concordance with the following criteria:

do = D10 [Johnson 1972]

The most frequent grain-size distribution of water-bearing sand layers in the "Kreka" coal basin is presented in a diagram (Figure 3) which indicates the grain-size distribution of filter material ranges from 1 to 4 mm.

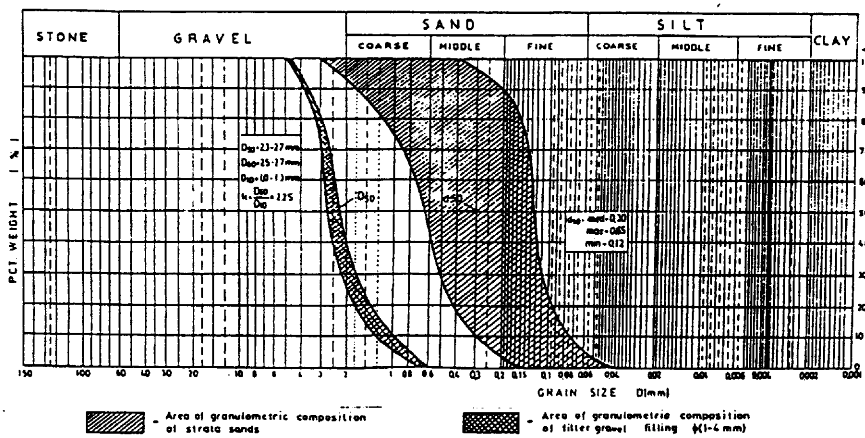


Figure 3. Representative size distribution diagram for borehole back- fill materials

WELL TYPES AND CONSTRUCTIONAL FEATURES

As already mentioned, a number of wells, designed to meet actual hydrogeological and geological conditions have been drilled. They can be classified into the following groups:

Type I: Standard Single Stage Well

These deeper wells are used for underground mine dewatering in a predominantly clayey rock and usually one dewatering well is used for dewatering one aquifer layer. The well is drilled by the rotatry method with a direct flushingwith drilling mud. The

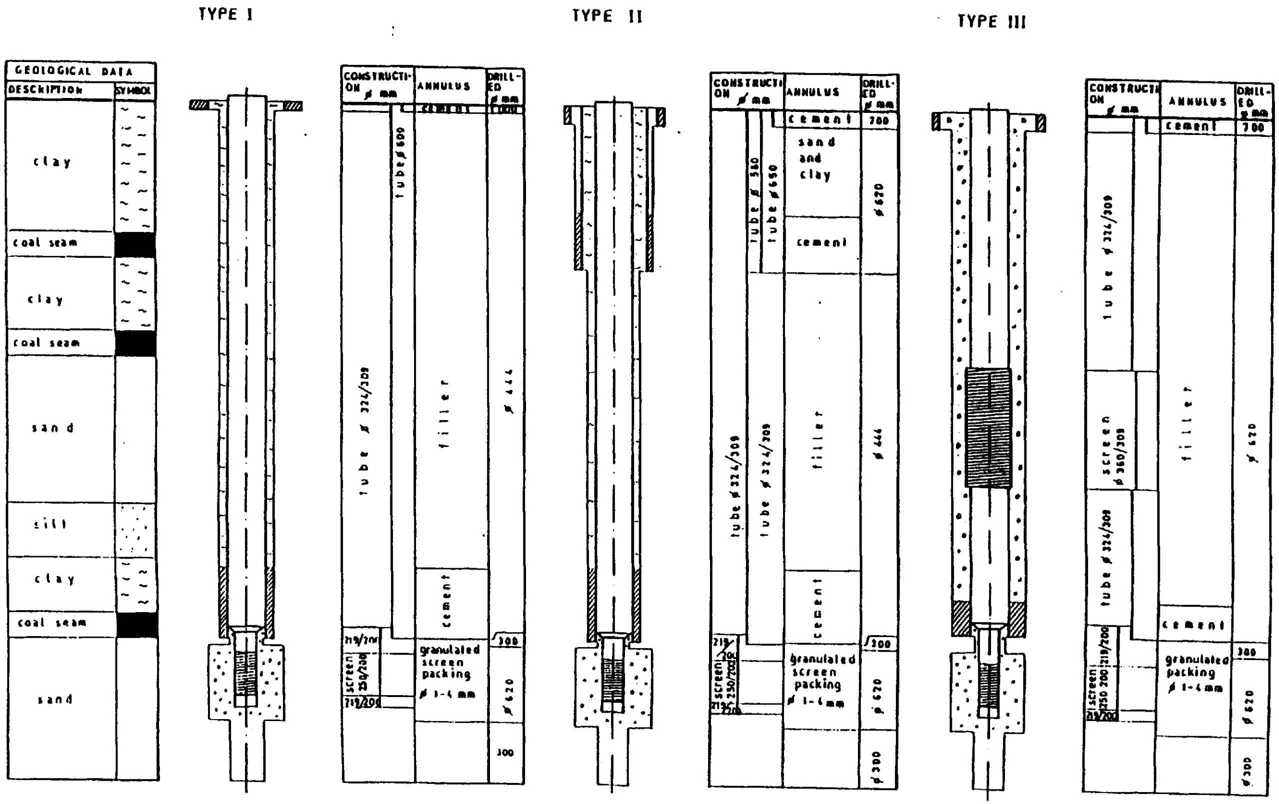


Figure 4. Types (I, II, III) of wells and constructional features

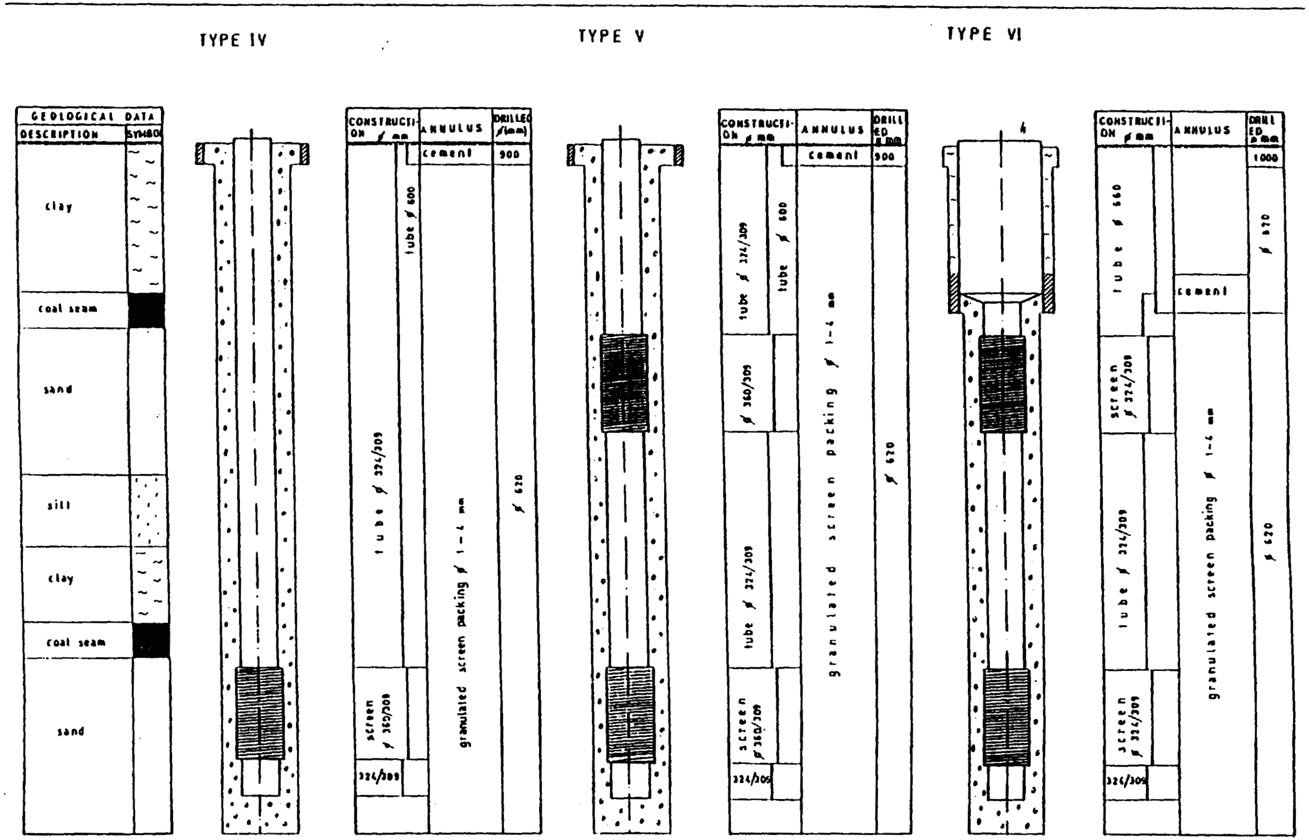


Figure 5. Types (IV, V, VI) of wells and constructional features

main features of the dewatering wells and major stages of their construction are given below:

- o direct drilling 445mm diameter borehole with flushing by bentonite drilling fluid;
- o installation of 324/309 mm diameter protective casing;
- o cementing the lower end of casing and filling the annulus between the casing and the borehole wall ;
- o drilling 300mm diameter borehole in water-bearing layer, with clean water as a flushing media,and reaming the borehole up to 620mm in diameter.;
- o filter installation of 240/202 mm, diameter filter and packing the annlus;
- o packing and insulation of water-bearing layer;

Type II: Reinforced Standard One Stage Well

These wells are used in areas where upper coal seams have already been mined out and the overlying strata has been damaged due to caving, so as it is necessary to construct a secure well. Usually, in the zone of old working a total loss of drilling fluid may take place. These wells are drilled by the direct methods. The main features of the dewatering wells and stages of their construction are given below:

- o drilling a 600/620 mm diameterborehole with flushing down to the mined out zone,
- o Installation of protective casing,
- o Drill rest opf the borehole as type I well.

Type III: Two-Stage, Directly Drilled Wells

These wells are used to dewater two or more aquifer layers but by maintaining of their mutual insulation.

Major construction steps for installing these boreholes are as follows:

- o direct drilling a 620 mm diameter borehole with flushing up to the coal seam,
- o flushing with water and reaming the borehole up to a 635 mm diameter in the upper aquifer layer,
- o installation of 324/309 mm casing with a diameter casing and 350/309 mm diameter filter,
- o cementing of annulus and packing
- o drilling 300 mm diameter borehole with water flushing and reaming in a lower aquifer layer up to 627 mm,
- o Packing and insulation of water-bearing layer.

Type IV: One-Stage Reversely Drilled Well

These wells are applied mostly to open pits dewatering systems, at smaller depths and mostly candy profiles.

The main construction steps are as follows:

- o drilling a 620 mm diameter borehole with a reverse flushing system by clean water,
- o installation of 324/309 mm diameter protective casing with 350/309 diameter filter in the aquifer layer in a sequence,
- o packing of annulus.

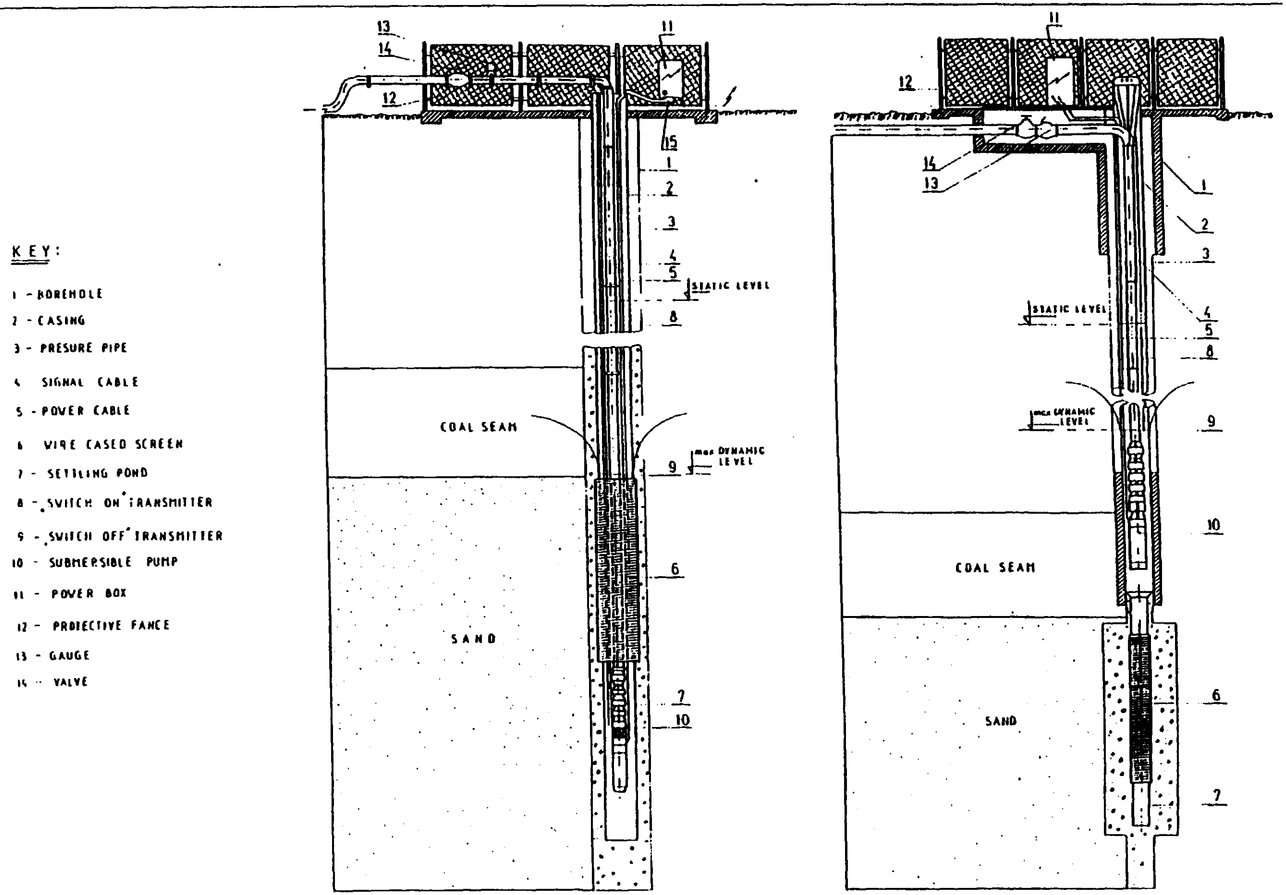


Figure 6. Two basic pump positions

Type V: Two-Stage (or Multi-Stage) Reversely Drilled Well

These wells are used at the same conditions as type IV, when it is necessary to dewater two or more water-bearing layers without inter-connecting the aquifers during the dewatering process. They are being continuously drilled with a reverse flushing by clean water through a number of water-bearing layers. Protective 324/ 309 mm diameter casing is installed with 350/309 mm diameter filtersinstalled in aquifer layers.

Type VI. Two-Stage (Multi-stage) Reversely Drilled Wells of a Widened Profile

This type of well is similar to the previous one in its function and the method of construction , but differs only in that the conductor casing is widened up. These wwells are particularly applicable to are appliedto conditions where the protective casings are not stable in extremely permeable ground or making difficulties to drilling in some other way. Therefore, continuous circulation and borehole stability are provided by a previous casing of a bigger profile through water-bearing layers.

The drawings of the above well types are given in Figures 4 and 5.

WATER PRODUCTION WELLS

In order to obtain a complete dewatering efficiency, it is necessary to provide optimal water withdrawal capacity. This, technically standard problem, is sometimes a limiting factor in a well operation, due to either extreme capacity requests and pumping height, or pumping aggregate dimensions, or technical features of available pumps. Regarding a number of wells with different exploitational requests, there is a number of pumps with a wide range of capacities and lifting heights, so for every concrete well, we select appropriate pump. Generally, we use submersible pumps of the PLEUGER type.

Their basic technical features are:

o	Capacity (Q):	2.5 to 25 l/s
o	Lifting height	(H): 60 to 450 m
o	Voltage (V):	500 or 865 V
o	Engine power (N):	7.5 to 140 kw
o	Coefficient of useful action:	0.7 to 0.8

Functionally, for the above well types, the position of a pump as well as dynamic water level related to well types part is important. Two basic pump positions are shown in Figure 6. They are derived from spatial relationship between water-bearing layer and necessary dynamic water level drawdown. Hydraulic and,functionally, more favourable pump position is above the filter, but with open pits shallow wells, the pump is often located below the filters in order to obtain as maximum drawdown-up to the filter tip-as possible.