

**HYDRODYNAMIC INVESTIGATION IN BOREHOLES
WHILE GROUTING WATER-BEARING FORMATIONS**

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ABSTRACT

This paper deals with principal issues of methods, techniques and process schemes of hydrodynamic investigations which must accompany grouting operations according to the integrated method for grouting developed at the specialized association "Spetstamponazhgeologia". Up-to-date level of this investigation ensures efficient water shut-off in sinking and driving.

The problem of controlling water inflows while driving or shafting is one of the most complicated and pressing in mining operations. Presence of water inflows sharply decreases rates of mine construction and leads to considerably higher costs.

At the association "Spetstamponazhgeologia", as a result of a comprehensive program of research, designing and testing, a new highly effective method for water shut-off in construction of mining workings, there was developed and applied to various regions of the USSR.

The following information on methods, techniques and process schemes of hydrodynamic investigations is the integral issue of the method. Taking into account the fact that efficiency of projecting and carrying out grouting depends completely on accuracy and quality of hydrogeological data, the integrated method attaches paramount importance to these investigations.

To obtain hydrogeological information /which is necessary for projecting grouting operations/, a complete program of investigations is accomplished in a borehole. The parameters that are determined, include: depth of occurrence; anticipated water inflow and strata pressure; filtration

factor; location of fractures and their size; geometry of fractures; rate and direction of underground water flow. On the basis of the above data the number of grouting holes and their spacing are determined, the type of grout is chosen and injection process parameters are calculated. During the course of grouting operations hydrodynamic investigation is also being accomplished to control quality results. This allows a display of the changing rock filtration properties in the course of injection and presents the possibility for effectively monitoring the process of grouting.

To carry out hydrodynamic investigations, a series of instruments have been developed at the specialized association "Spetsstamonazhgeologia": downhole flowmeters "DAU-3M-34", "DAU-3M-57", "DAU-3M-73", "DAU-3M-108" /with the outside diameter from 0.034 to 0.108 m/; downhole instrument for fixing the direction of underground water flow "DAU-6"; and packers "DAU-I" type with the outer diameter from 0.057 to 0.200 m. All of the instruments successfully work both in uncased and cased boreholes. The flowmeters provide measuring of flow rate in the range of $0.001 \cdot 10^{-3}$ to $50 \cdot 10^{-3}$ m³/s and more; their accuracy for uncased holes is 1%. The flowmeters can be run in any liquid present in a borehole: mud, mineralized strata water, oil etc. Accuracy of fixing the direction of underground water flow by the "DAU-6" device amounts to ± 5 degrees. The "DAU-I" type packers can withstand pressures up to 50 MPa.

The principal method of hydrodynamic investigations in grouting is flowmetering. These tests are carried out in the course of drilling upon intersection of every water-bearing stratum. Testing begins with cavernmetering. Following this, a packer is run down the hole and is placed in the upper layer of the tested stratum. Then the flowmeter is run down the hole. Such a process scheme makes it possible to accomplish both pumping and injection testing. If it is necessary to carry out pumping tests, the upper section of drilling tubes, on which the packer is run down, should be of a bigger diameter to let the pump into the hole.

Each stratum is tested at not less than 3 rates while pumping or injecting water with constant outflow. Flowmetering consists in slow running the instrument and fixing the speed of rotation of a sensing unit. After finalizing each pumping/injection test, the process of strata pressure recovery is controlled.

The flowmeters enable determination of the location of aquifers; number and depth of occurrence of fissures and cavities; outflow of liquid from each fracture and cavity, and also their size and geometry.

The strata pressure recovery graph allows the filtration factor, anticipated water inflow, skin effect, strata pressure and type of an aquifer to be determined.

The "DAU-6" device enables the direction of underground water flow in fractures and cavities and geometry of the main fissuring to be obtained.

The above mentioned parameters are evaluated according to methods developed at the association "Spetstamponazhgeologia".

Quality control of grouting is also accomplished by hydrodynamic methods. The quality control method is based on a repeated testing of the aquifer before starting grout injection. Besides, the course of injection is monitored by the control station SKTs-2M which registers the following characteristics: pressure fluctuation; pumping unit output; volume of injected grout and its properties. Special interpretation of these data allows determination of the actual distribution pattern of grout, quality of filling the voids within the created isolating curtain and residual influxes. The quality control method makes it possible to ensure the calculated value of permeability factor decrease and, as a result, permits in all cases cutting down water inflows into a would-be mining working to the needed amount.

High efficiency of the above methods was proved by their application to 93 mining projects. The use of these methods gives possibility to sharply increase efficiency and reliability of grouting operations in mine construction and gain considerable cost savings.