Vibratory rotary drilling of borehole using HIGH-FREQUENCY CAVITATING HYDROVIBRATOR

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Foreword

The high-frequency cavitating hydrovibrator is used for the vibratory rotary drilling of firm rocks.

The advantage of this method is that it combines the positive characteristics of vibrating and rotary drilling methods. During such combined method of drilling there are not only static forces to the rock from the rock cutting tool, but also dynamic influences of periodic character (high frequency shock impulses).

The rock is not only crushed and spalled by rock cutting tool under the influence of these forces in the impact moment, but is cut off or spalled during rotation of drilling tools under the influence of static loads to the breed.

Application and field of application

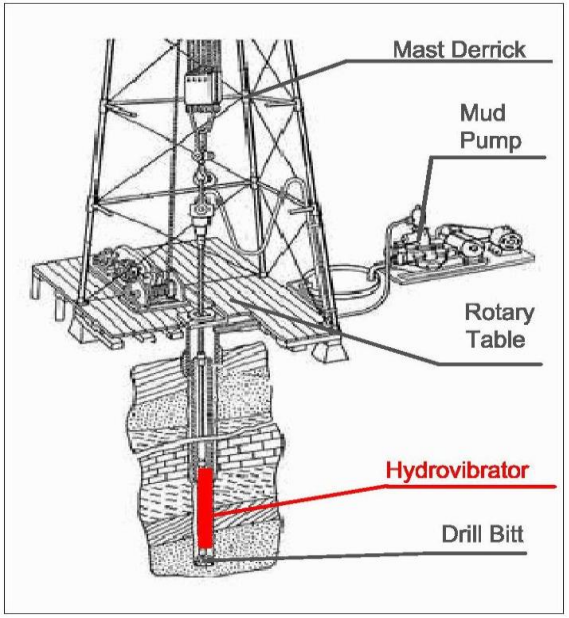
The high-frequency cavitating hydrovibrator of oscillations is designed to the intensification of borehole drilling irrespective of depth and hardness of penetrated breeds.

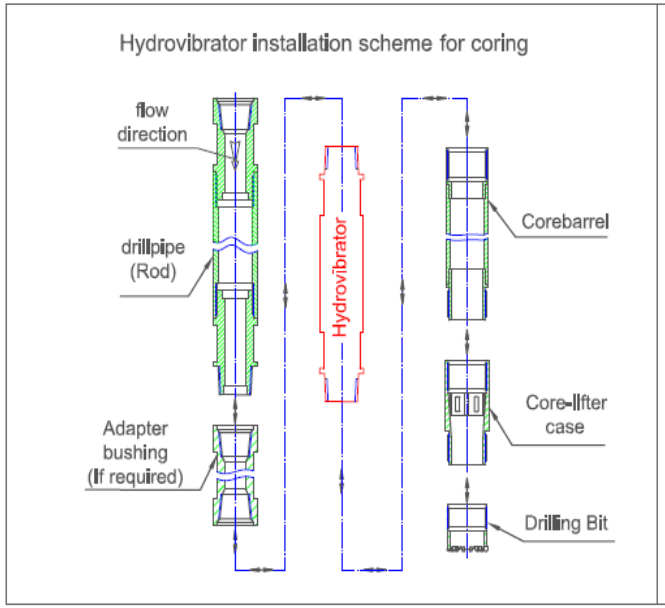
Field of application:
- Expendable well;
- Oil and gas drilling;
- Hard-rock borehole drilling;
- Technological drilling.

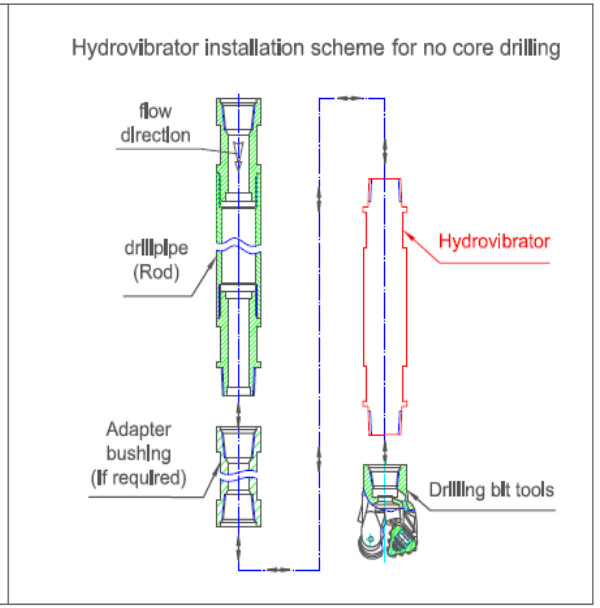
Applicable for the drilling of vertical and horizontal boreholes.

Cavitation hydrovibrator does not require essential expenses for implementation and can be used for any equipment where the washing liquid is used.

Hydrovibrator operating principal







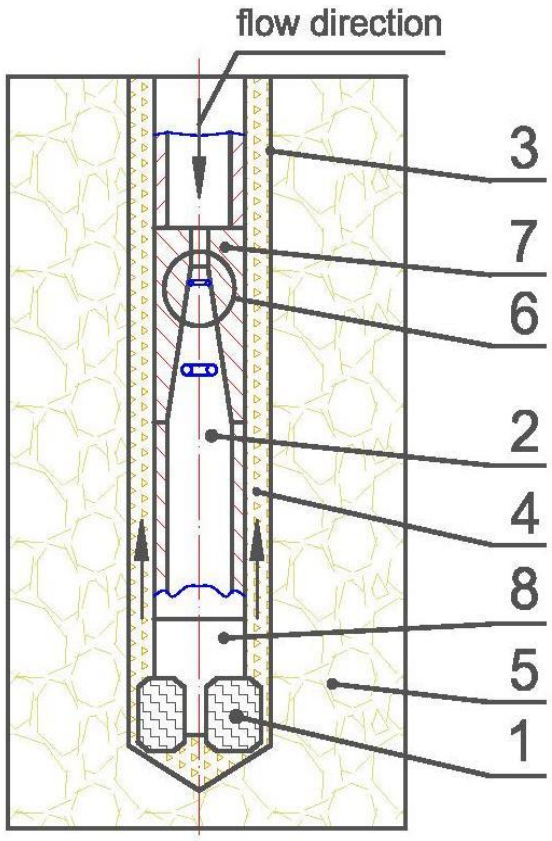
The high-frequency cavitating hydrovibrator is installed to the drilling liner and placed in a vertical or horizontal well.

The washing fluid under pressure is supplied to the inlet of the high-frequency cavitating hydrovibrator by the drill pump through the driliing pipes.

Further washing fluid passes through the flowing channels of the hydrovibrator to the well.

The powerful high-frequency pulsing stream occurs due to the pressure drop in the flowing channel of the high-frequency cavitation hydrovibrator. Part of pulsing stream energy transforms in to longitudinal high-frequency accelerations which has impact to the rock cutting tool.

Operation description of hydrovibrator

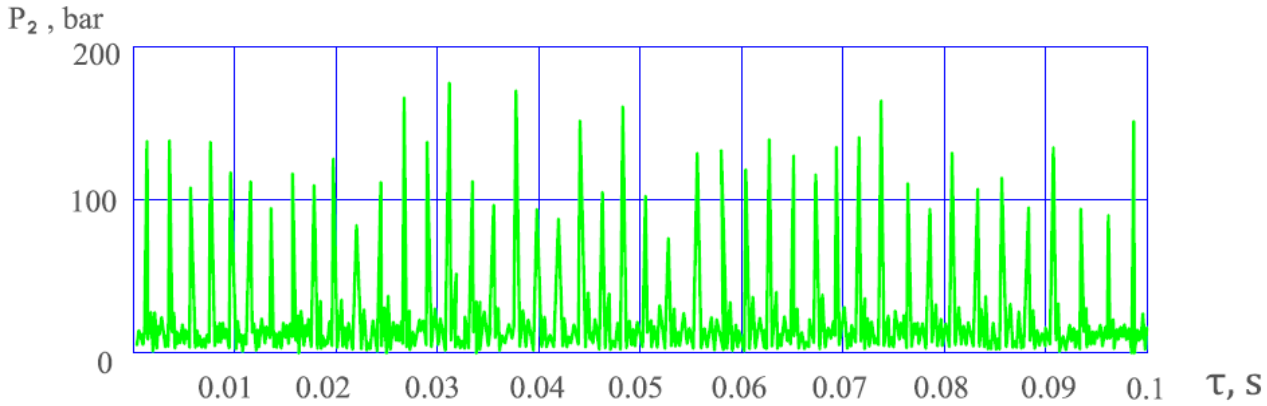


Schematic representation of the vibration-rotational drilling using cavitation hydrovibrator

Hydrovibrator creates high-frequency longitudinal vibration acceleration of rock cutting tool 1, using for this purpose part of the energy of drilling fluid flow 2, supplied to the hole 3 for cleaning the face from the particles 4 of pulverized rock 5. Hydrovibrator is a part of the tool string. The inner channel 6 with a special profile in the body 7 of hydrovibrator ensures the existence of the regime of periodically stalling cavitation during the washing fluid is passing through this special profile. Hydrovibrator is installed either immediately over the rock cutting tool 1 or at some distance from the rock cutting tool (for example, over the core barrel). Hydrovibrator converts the steady flow of drilling fluid in pulsating flow. In this case part of the vibration energy of drilling fluid will be transferred to the drill string 8 between hydrovibrator and rock cutting tool. This causes the development of longitudinal vibrations of rock cutting tool.

In specially profiled hydrovibrator channel occurs periodic formation and growth of cavitation cavity . After reaching its maximum size, corresponding to appropriate flow regime, occurs separation of cavitation formation and its carrying downstream. The abnormally high pressure is occurred in the fluid flow during the collapse of cavities for the large volume. The wave of pressure goes downstream from the collapse cavity center for relatively large distances, practically without decaying. The pressure wave which goes upstream is suppressed by the new cavity which was growed up in this moment . As evidenced by the absence of oscillations at the entrance to hydrovibrator. However it takes part in the formation of reverse flow and creates conditions for the separation of the next cavern. Thus in hydrovibrator established self-regulating process of detachment and collapse of cavitation cavities.

Operation description of hydrovibrator



Oscillogram fragment of pressure oscillations P_2 at the outlet of the hydrovibrator for input pressure P_1 = 41 bar and P_2 / P_1= 0,17 the cavitation parameter

This figure shows the oscillogram of pressure oscillations at the exit of hydrovibrator. The regime periodically stalling cavitation with increasing depth of wells will be achieved by maintaining the appropriate pressure at the inlet hydrovibrator. As far as the pressure oscillations of washing liquid caused by the regime of periodically stalling cavitation do not goes upstream, **then the mud pump will operate without the dynamic loads on its hydraulic system.** Thus, hydrovibrator ensure elimination of weaknesses inherent in existing hammers and vibrators.

Operation description of hydrovibrator

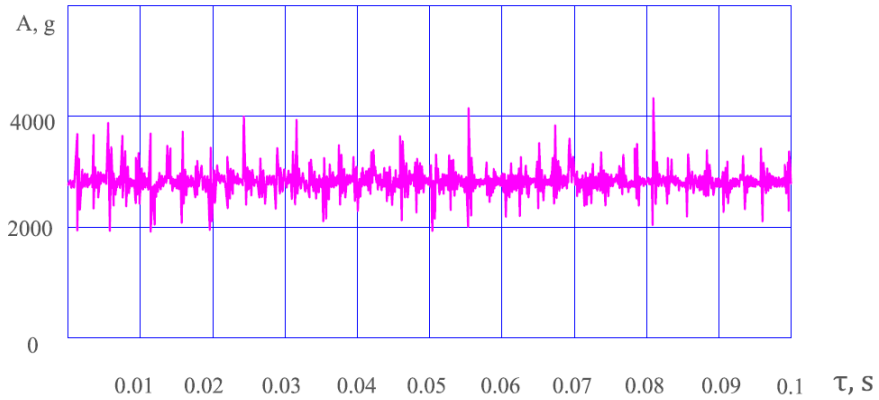


Figure 1. Oscillogram of vibration acceleration at the section of hydrovibrator for the inlet pressure P_1 = 41 bar, P_2 /P_1 = 0.17 the cavitation parameter and 450 Hz frequency.

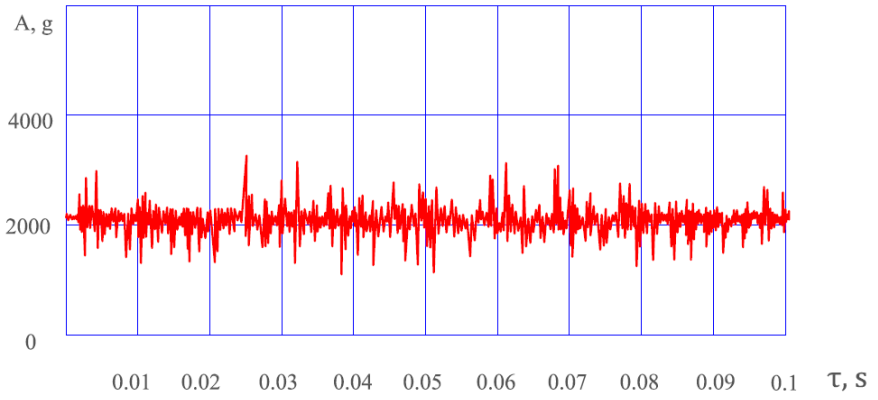
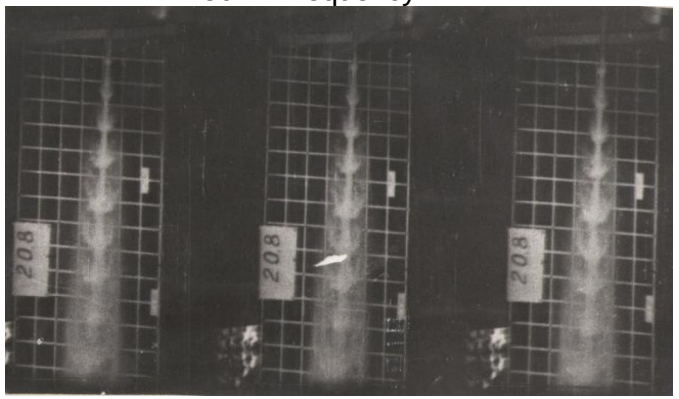


Figure 2. Oscillogram of vibration acceleration at the rock-cutting tool for the inlet pressure P1 = 41 bar, P2 /P1 = 0.17 the cavitation parameter and 450 Hz frequency.

Figure 1 shows us the constant value of vibration acceleration at the section of hydrovibrator which is 2850 g. This constant value of vibration acceleration reaches the 4250 g maximum value in the peak.

Figure 2 shows us that constant value of vibration acceleration at the rock-cutting tool slightly less in comparison with the section of hydrovibrator and this value is 2400 g . In this case the constant value of vibration acceleration reaches the 3200 g maximum value in the peak.



Picture 1. The fragment of high-speed video filming (2980 frame per second) demonstrates the pulsing flow at the outlet of hydrovibrator.

Описание работы гидровибратора

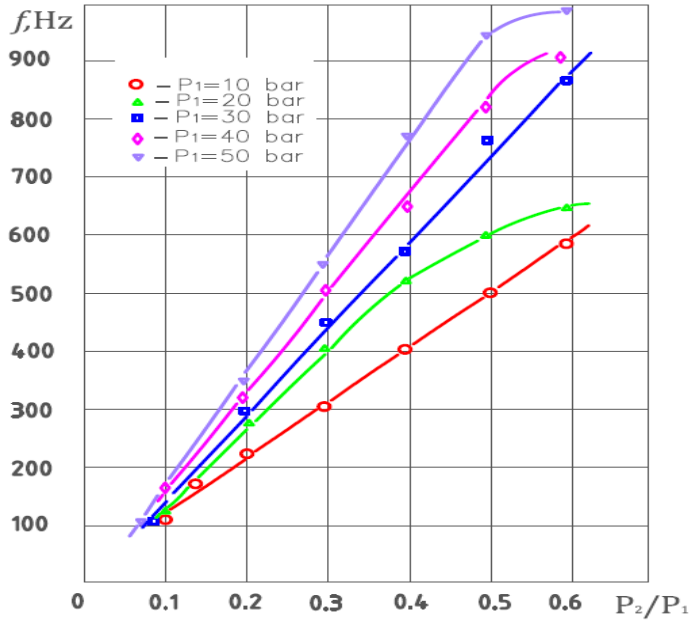


Figure1. Dependence diagram
of frequency from cavitation parameter

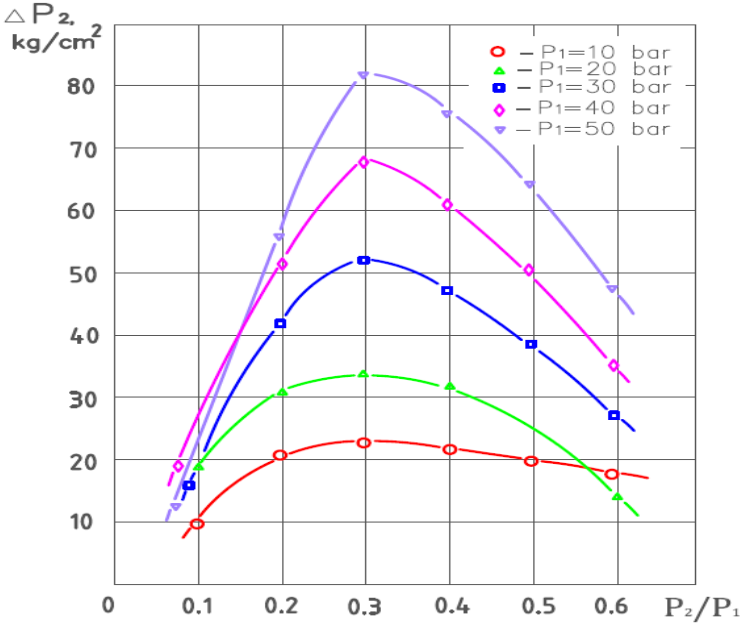


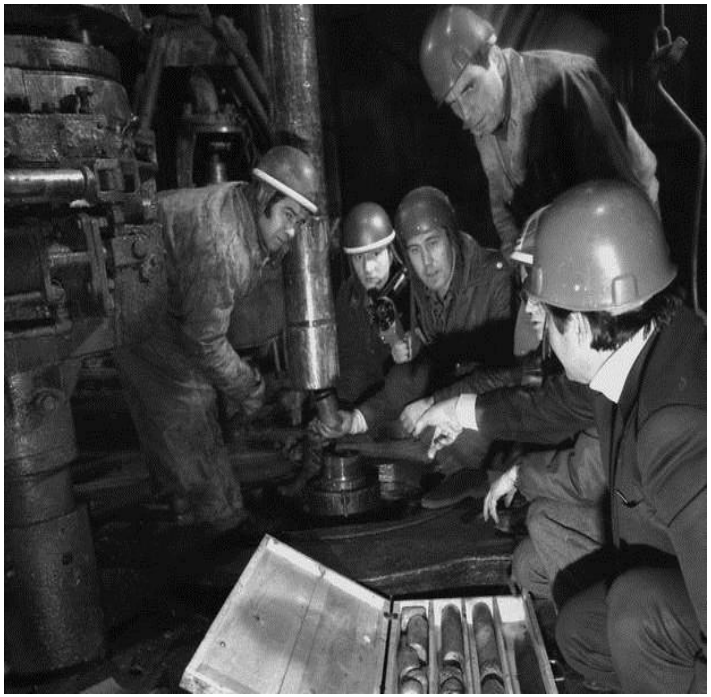
Figure 2. Dependence diagram
of pressure peak-to-peak motion from
cavitation parameter

Figure 1 shows experimental dependences of frequency from cavitation parameter at the hydrovibrator outlet. Cavitation parameter is pressure ratio P_2/P_1; P_2 - outlet pressure and P_1 - inlet pressure.
In case of cavitation parameter increasing the oscillation frequency is rising from 100 to 900 Hz and more.

Figure 1 shows experimental dependences of peak-to-peak motio of pressure value ΔP_2 from cavitation parameter at the hydrovibrator outlet. Cavitation parameter is pressure ratio P_2/P_1; P_2 - outlet pressure and P_1 - inlet pressure.
In this case maximum value of ΔP_2 pressure peak-to-peak motion is 80kg/cm^2 under the cavitation parameter is P_2/P_1 =0,3.

Indicated dependences is described for different P_1 - inlet pressure of hydrovibrator.

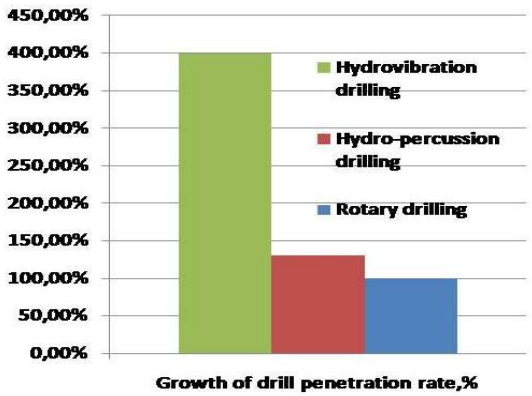
Testing

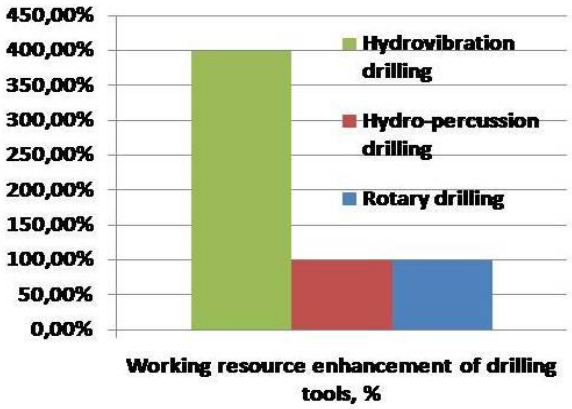


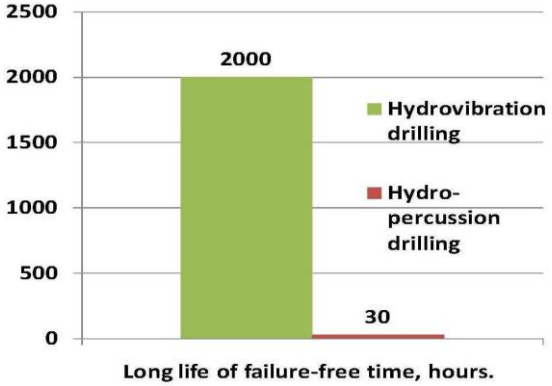
The hydrovibrator has passed tests:

- In the lab environment for the borehole drilling with diameter from 36 up to 250 mm and depth up to 4000m;
- In the field environment for the borehole drilling with diameter from 76 up to 190mm.
- The testing was conducted in conditions of sedimentation rocks and granite with coring manner using diamond drill bits and with no coring manner using three-roller bit.

The main advantages of the hydrovibrator







✓Growth of drill penetration rate in comparison to rotary drilling method can be up to 400%;

✓Working resource enhancement of drilling tools can be up to 400%;

✓Long life of failure-free time is 2000 hours;

The main advantages of the hydrovibrator

•The supplementary power source is not necessary;
•Readjustment for deferent drilling depth is not necessary;
• Expansion of longitudinal vibration upstream to drill string does not exist;
• Movable and rotation equipment detail/part does not exist;
• Increase of core recovery for drilling of fractured rock;
• Limit on drilling depth does not exist;
• Limit on drilling diameter does not exist practically;
• In consequence of hydrovibrator transforms the stationary flow of washing fluid in to pulsating stream the lifespan of rock-cutting tools is increased due to following factors:

- Cleaning power of rock-cutting tools is increased;
- Cooling of rock-cutting tools is increased;
- Return of drilled solids is increased;

• Hydrovibrator creates high-frequency accelerations up to 20000 Hz;
• Hydrovibrator usage does not effect negatively to drilling equipment. Vibration reducing of drilling equipment and rig was fixed during the testing.

The main advantages of the hydrovibrator

• Consumed power to drillstring rotation is reduced by 20-25 % due to hydrovibrstor usage. This allows to increase the axial load.
• Our equipment allows changing drilling manner to the vibration-rotational method of drilling with minimum expenses and does not have weaknesses inherent in existing hammers and vibrators such as readjustment for deferent drilling depth, breakaways, keying on, short life and other.

The high-frequency cavitating hydrovibrator is environmentally friendly, it works on clear water without using chemicals that harm the environment and contaminate groundwater.

Offer

• Engineering service;

• Design and producing of high-frequency hydrovibrator for the certain operating conditions of drilling equipment;

• We are ready to demonstrate the capability and working efficiency of hydrovibrator in special operating conditions at the environment of customer drilling equipment;

• It will include follow: development, design of hydrovibrator for conditions and equipment of certain customer company as well as producing and testing.

We need the following initial data for this:
• Diameter of a borehole;
• The rate of flow and a pump head;
• Drilling depth;
• Type and model of your equipment;
• Clamping type of drilling tools (thread etc.).

Thank you for attention

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