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Issue Article

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THE PROGRAM FOR SELECTING THE BOTTOM-HOLE ASSEMBLY FOR DRILLING FOR DRILLING IN AN ELONGATED DIRECTION AND UNDER THE CONDUCTOR OF THE DIRECTIONAL BOREHOLE

Abstract: *The article presents the design of the bottom-hole assembly (BHA) of the elongated direction and the conductor of the directional production and evaluation well for the purpose of successful drilling of well No. 707 of the Western Cheleken field in the coastal zones of the coastal waters of the Caspian Sea.*

Materials from previously drilled wells and standard calculations, as well as safety rules in the oil and gas industry, were used to design the BHA of the extended direction drill string and the well conductor.

This work can be useful and used to perform the tasks set when drilling vertical wells and preventing trunk curvature, as well as bringing the wellbore to the vertical in case of its curvature in conditions of abnormally high reservoir pressures.

Key words: *conductor, coupling, casing pipes, downhole engine, centralizer, calibrator, drill collar , bit, pressure drop, turbobur, electric drilling, mudstone.*

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Introduction

To ensure the design trajectory of the borehole, it is necessary to apply the most effective bottom of the bottom-hole assembly (BHA) for these drilling conditions.

The selection of the BHA should be made taking into account the provision of an effective diameter of the wellbore for the smooth passage of the casing string, the exclusion of ledges and guttering.

The optimal number of casing strings and the installation depth of their shoes in the design of wells is determined by the number of zones with incompatible conditions of the trunk wiring according to the gradients of reservoir (pore) pressures and hydraulic fracturing (absorption) pressures of formations, strength and stability of rocks [1].

The shoe of the last casing, overlapping the rock prone to fluidity, should, as a rule, be installed below their soles.

Prior to the opening of productive and pressure aquifers, it should be provided for the descent of at least one intermediate column or conductor to a depth that excludes the possibility of rock rupture after complete replacement of the drilling fluid in the well with reservoir fluid and sealing of the mouth.

For the obliquely directed operational evaluation well № 707 on the Western Cheleken field, the following design was provided for an elongated direction and a conductor, which is given in Table 1.

Table 1. Well design (characteristics of casing pipes and depth of descent).

Hole name	Descent depth (m)		Diameter of the open barrel (diameter of the bit) (mm)	Outer diameter, diameter wall thickness, strength group (mm)	Weight of casing pipes (tons)
	above	below			
Mining direction	0	7	914	720 x 10 St.3.	1,58
Elongated direction	0	50	660,4	508 x 11,13 J55	6,94
Conductor	0	800	444,5	339,7 x 9,65 J55	64,3

The required diameter difference between the walls of the well and the casing couplings should be selected based on the optimal values established by drilling practice and maximally ensuring unhindered descent of each casing to the design depth and their high-quality cementing [2].

The minimum allowable diameter difference between the casing couplings and the borehole wall is shown in Table 2.

Table 2.

Nominal diameter of casing pipes, mm	114 127	141 146 159	168 194	219 245	273 299	325 351	375 426
Diameter difference, mm	15	20	25	30	35	45	50

Deviations from these values should be justified in the project.

The minimum allowable diameter difference between the casing couplings and the borehole wall is created by choosing the appropriate BHA of the drill string for each interval of casing descent [3].

First of all, drill bits is selected from the bottom to the top in accordance with the diameter of the casing strings and, accordingly, according to calculations, choose drill collar, calibrators (centralizers), downhole motors, drill collar, translators.

The choice of bit types should be based on the physical and mechanical properties of rocks (hardness, education, plasticity, etc.), lithological section, rock movement, etc. In addition, it is necessary to know the intervals of core sampling and the characteristics of the selected rocks (loose, loose, hard, strong, etc.).

When choosing the type of bit, it is also necessary to take into account data on the possible durability of the bits and the mechanical speed obtained from the results of working out the bits in this area (by area); at the same time, the wear of the bits should be taken into account. If such materials are not available for this deposit, then in this case it is possible to use information on other areas with similar geological conditions [4].

A rational type of bit of this size for specific geological and technical drilling conditions is a type that, when drilling under the conditions under consideration, provides a minimum of operating costs per 1 m of penetration.

Diamond bits can be used for drilling limestones, mudstones, dense clays, clay sandstones, marls, anhydrites and other rocks in which the effectiveness of the use of roller bits is sharply reduced. In the intervals composed of flint limestones, quarried sandstones, highly abrasive siltstones and other hard abrasive rocks, it is not recommended to use diamond bits. The expediency of using diamond bits should be ensured by regulatory savings [5].

The main element for the BHA is weighted drill collar, which create rigidity to the layout and their weight axial load on the bit.

Table 3.

Bottom-hole assembly (BHA)	Diameter (mm)					
Bit	139,7–146	149,2–158,7	165,1–171,4	187,3–200	212,4–228,6	244,5–250,8
Drill collar: (weighted drill collar) under normal conditions	114	121 (133)	133 (146)	159	178	203
in complicated conditions	108	114	121	146	159	178
Bit	269,9	295,3	320	349,2	374,6-393,7	>393,7
Drill collar: under normal conditions	229	245	245	254	273	273
in complicated conditions	203	219	229	229	254	254

The calculation of the drill collar is reduced to determining their diameter and length. The diameter of the drill collar is determined based on the conditions for ensuring the greatest rigidity of the section in drilling conditions, and the length - based on the load on the bit.

Changing the BHA during drilling in the direction of increasing rigidity is not recommended. Each change in the stiffness of the BHA must be technologically justified, verified by calculation and recorded in the regime-technological map. In case of extreme necessity, an increase in stiffness is allowed only after careful study of the open borehole.

The ratio of the diameter of the drill collar to the diameter of the well should be possibly large (0.75-0.85 for bits with a diameter up to 295.3 mm, 0.65-0.75 with a diameter over 295.3 mm) [6].

Depending on the diameter of the bit and drilling conditions, according to Table 3, the diameter of the drill collar is selected.

For complicated drilling conditions, the diameter of the drill collar for bits with a diameter of more than 250.8 mm is allowed to be reduced to the nearest adjacent size.

In turbine and electric drilling, the diameter of the drill collar should not exceed the diameter of the turbobur or electric drill, therefore, the diameter of the submersible engine is taken as the largest size of the drill collar [7].

After selecting the diameter of the drill collar according to Table 4, we check whether the above-ground section of the drill collar provides the necessary rigidity of the casing string under which drilling is carried out. The rigidity of the drill collar section must be no less than the rigidity of the casing string (Table 4).

Table 4.

Pipes	Diameter (mm)											
Drill collar Casing	108 114	121 127	146 146	159 168	178 178	178 219	203 245	203 273	229 299	229 324	229 351	254 ≥377

After checking the rigidity according to Table 5, the diameter of the drill collar is selected depending on the diameter of the previous casing and the drilling method.

Table 5.

Pipes	Drilling method	Diameter (mm)										
Casing	Downhole engine	-	-	-	-	-	178	194	219	245	273	299
	The rotor	114	127	140	146	168	178	194	219	245	273	≥299
Casing	Downhole	-	-	-	-	-	89	102	114	127	140	140

	engine										146	146
	The rotor	60	60	73	73	89	89	102	114	127	140	140
Casing	Downhole engine	324	340	≥406	-	-	-	-	-	-	-	-
	The rotor	-	-	-	-	-	-	-	-	-	-	-
Casing	Downhole engine	140 146	140 146	168	-	-	-	-	-	-	-	-
	The rotor	-	-	-	-	-	-	-	-	-	-	-

If the casing is made up of pipes of two diameters, then the drill string can also be completed from pipes of two diameters [8, 9].

Having selected the diameter of the drill collar, we check its ratio (and if the column is made up of pipes of two diameters, then the ratio of the diameters of the pipes located above the drill collar) to the diameter of the drill collar. If this ratio is less than 0.75, then select drill collar of several diameters decreasing to the diameter of drill collar. The dimensions of the above-ground section of the drill collar must correspond to those specified in Tables 3 and 4.

Having determined the diameter of the drill collar, we calculate their length (rotary method) by the formula:

$$L_{dr.c.} = 1{,}25 P_{bit.} / q_{dr.c.} \qquad (1)$$

where P_{bit} is the load on the bit, MN;

$q_{dr.c}$ – weight of 1 meter drill collar, MN;

$L_{dr.c}$ – length of drill collar, meters.

When drilling with downhole motors, the length of the drill collar is determined by the formula:

$$L_{dr.c.} = 1{,}25 P_{bit} - G / q_{dr.c.} \qquad (2)$$

where G is the weight of the downhole engine, MN.

If the drill collar consists of pipes of several diameters, then their total weight should be equal to

$$q_{dr.c.1}L_{dr.c.1} + q_{dr.c.2}L_{dr.c.2} + \ldots\ldots q_{dr.c.n}L_{dr.c.n} = 1{,}25 P_{bit} \qquad (3)$$

or when drilling with downhole motors

$$q_{dr.c.1}L_{dr.c.1} + q_{dr.c.2}L_{dr.c.2} + \ldots\ldots q_{dr.c.n}L_{dr.c.n} = 1{,}25 P_{bit.} - G \qquad (4)$$

After that, we determine the axial critical load of the P_{cr}, according to the formula

$$P_{cr.} = \sqrt[3]{EIq^2} - P_0 F_0 \qquad (5)$$

where E is the elastic modulus (2.1 x 107 N/cm^2);

I is the equatorial moment of inertia of the pipe section, cm^4;

q is the weight of the unit of length of the drill collar, N/cm;

P_0 is the pressure drop on the bit, N/ cm^2;

F_0 is the total area of the bit holes, cm^2.

$$I = \pi/64\left(D^4 - d^4\right) \qquad (6)$$

If the critical load is less than the load on the bit, then in order to limit the transverse deformation of the drill collar and the contact area with the well, it is recommended to install intermediate profile cross-section supports on the drill collar, if necessary. The number of supports is calculated by the formula

$$m = P_{bit.} - Q_к / q^{\alpha}_{dr.c.} - 1 \qquad (7)$$

where Qa is the weight above the bit arrangement to combat the curvature of the wellbore, MN;

α is the distance between the supports (the number of supports should not be less than two), the value of α is given in Table 6.

Table 6.

Drill collar diameter (mm)	Distance between supports (in m) for different rotational speeds, in rad/s (rpm)			
	5,23 (50)	9,42 (90)	12,56 (120)	15,7 (150)
108 – 114	20,0	16,0	13,5	12,0
121	22,0	16,5	14,0	13,0
133	23,5	17,5	15,0	13,5
146	25,0	18,5	16,0	14,5
159	31,0	21,5	18,5	17,0
178	33,0	23,5	21,0	19,0

The types of centralizers (calibrators) for each interval are selected according to the drilling conditions and the dimensions should be correspondingly equal to the diameter of the bit. [10, 11].

Based on calculations for drilling an interval from zero to 50 meters for an elongated shaft direction with a diameter of 720 mm, the following BHA was selected.

Crab 914 mm- 0.6 m; calibrator 660.4mm – 1.3 m; drill collar 245mm – 6.5m; calibrator 660.4mm – 0.6 m; drill collar 229mm – 13m; calibrator 660.4mm – 0.6 m; drill collar 203mm – 18m.

BHA for drilling for a conductor with a diameter of 426 mm.

Interval 0-600 m:

Bit with a diameter of 444.5 mm-0.5 m; calibrator 444.5 mm – 1.3 m; drill collar 245 mm – 6.5 m; calibrator 444.5 mm – 1.3 m; drill collar 229 mm – 13 m; calibrator 444.5 mm - 1.3 m; drill collar 203 mm – 60 m; drill collar.

Drilling was carried out vertically by rotary method. A diamond bit was used for drilling under the conductor. The hydraulic well drilling program provided the most complete cleaning of the face and the borehole from the drilled rock with minimal hydraulic losses. The working pressure of pumping pumps was 0.75 – 0.8 of the permissible, for the applied sizes of cylinder bushings [12].

The specific consumption of drilling mud when drilling the interval under the elongated direction by the rotary method was within 0.035 – 0.05 l/s cm^2 of the face area, and when drilling under the conductor with a hydraulic downhole motor did not exceed 0.07 l/s cm^2. Upon reaching a depth of 800 meters, a complex of geophysical studies was carried out. The iklinometric data showed the verticality of the trunk, which corresponded to the project.

Conclusions.

1. The calculated selection of the BHA for the elongated direction and the conductor provided with their rigidity to successfully drill an obliquely directional operational and evaluation well, up to the provided design depth, ensuring the verticality of the trunk.
2. The correct selection of the BHA for the elongated direction and the conductor, which alternates with soft weakly cemented abrasive rocks, proves the verticality of the drilled trunk.
3. This method of collecting the BHA can be used when drilling deep wells with abnormally high reservoir pressures and can be useful to design engineers drilling oil and gas wells.

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