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Issue Article

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CHOOSING THE PROFILE OF AN INCLINED-DIRECTIONAL WELL

Abstract: *the article considers the design of the profile of an obliquely directed operational evaluation well for the purpose of successful drilling of well No. 707 at the Western Cheleken field in the coastal zones of the coastal waters of the Caspian Sea. To design the profile in order to avoid accidents and complications, materials of geophysical studies of previously drilled wells were used. And to prevent the collision of boreholes, the Close Approach program was used, as well as safety rules in the oil and gas industry.*

This work can be used to perform the tasks set when drilling directional wells, to combat possible complications in the open hole, as well as to prevent the risk of collision of boreholes.

Key words: *risk, hole collision, program, complication, accident, absheron, akchagil, red-colored thickness, curvature, displacement, cost, stabilization.*

Language: *English*

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Introduction

Currently, the oil industry of Turkmenistan is facing the issue of involvement in the active development of hard-to-recover oil reserves, the bulk of which is located in low-permeable reservoirs. The importance of solving this problem is determined by the depletion of reserves in long-exploited areas with a sharp decrease in well productivity.

In foreign practice, drilling of inclined and horizontal wells is widely used, where a reduction in the cost of oil production and an increase in the coefficient of hydrocarbon extraction have been achieved.

The experience of drilling such wells for a number of years in various countries has shown that for successful and economically justified drilling, the following is necessary:

- high engineering qualification of the staff;
- availability of reliable geological data that are necessary for the design and wiring of a particular well;
- creation, development, production and application of special devices and equipment;
- latest software;
- the use of special drilling fluids in some cases;
- new technologies and devices for well completion.

The wiring of wells with various hole deviations in new and old fields is carried out using devices for hole deflection and downhole telemetry systems for controlling the hole trajectory with appropriate software.

In the presence of data on productive formations, it is necessary to choose the most economical technology, which is determined by the target task that the mining company sets before drilling, the properties of the formation and drilling conditions during the work. The most important factor of any project is engineering planning of processes using advanced technologies. In order to avoid undesirable consequences due to poor planning of work, it is necessary to use engineering knowledge of processes from specialists.

Of great importance in directional drilling is the correct choice of the well profile. The profile should be chosen in such a way that, with minimal time and money, the well should be brought to the design depth without complications, ensuring proper quality for long-term operation. The rational profile makes it possible to minimize the work with the diverter, to ensure the necessary displacement of the face and the permissible intensity of curvature, as well as free passage along the hole of the bottom of the drill string layout. The profile should allow the well to be operated with deep pumps, including rod pumps, and the wiping of the casing pipes with rods and their breakage should be excluded.

The choice of the profile type is carried out taking into account: the requirements of drilling wells; the strength characteristics of the rocks composing the geological section of the deposits; the patterns of curvature characteristic of the used bottom-hole assembly (BHA); methods and technical means used in the operation of wells. The profile of the well should provide a minimum value of the load on the hook when lifting the drill string (downhole equipment).

Directional wells should be drilled with minimal time and money. The project for the construction of a directional well should include: justification of the choice of profile configuration, calculation and construction of the profile, determination of permissible deviations of the hole from the project. The profile of the directional well must satisfy high-speed and high-quality drilling, have a minimum number of bends, be technically feasible and economically feasible.

There are two types of profiles: conventional and spatial. Profiles of the usual type are a curved line located in one vertical plane; profiles of the spatial type are a spatial curved line.

Directional production and evaluation well № 707 on the West Cheleken area was laid with a design vertical depth of 2620 meters (along the hole of 2764.37 meters) in order to assess the reserve of hydrocarbon raw materials and increase oil production using advanced technologies of foreign companies, as well as the resumption of oil and gas production from the mothballed field.

The project for the construction of an operational evaluation well № 707 with a depth of 2620 m (vertical) 2764 m (along the hole) at the field in question was developed on the basis of a combined pressure graph in drilled wells and calculations of the hole trajectory. That is, the guide shaft with a diameter of Ø708 mm was lowered to a depth of 7 m (vertically) and secured with rubble concrete. An elongated direction with a diameter of 508 mm was lowered to a depth of 50 m, to overlap weakly cemented sandstones. The conductor Ø=339.7 mm was lowered to a depth of 800, to overlap unstable layers of the horizons of Absheron, akchagil and unstable water layers, as well as possible gas layers of the upper part of the horizon of the red-colored thickness. The technical column Ø= 244.5 mm was lowered to a depth of 2100 m vertically and along the hole of 2119 m, to overlap water and possibly gas layers of the middle, lower horizons of the red-colored thickness, as well as to control the anti-discharge equipment in case of possible gas and oil occurrences. The operational column Ø = 139.7 mm, descended to a depth of 2620 m vertically and along the hole 2764 m.

Profile design procedure:

1) we study in detail the data on previously drilled wells, establish patterns of hole curvature, azimuth change, the influence of various factors on the change in the angle and azimuth of curvature.

2) using a structural map, which shows the position of the mouth and bottom of the projected well, we determine the initial data for calculating the profile: vertical and horizontal projections of the hole and the azimuth of curvature;

3) in accordance with the conditions of penetration, select the profile type;

4) set the length of the vertical sections;

5) select the layout of the bottom of the drill string and determine the intensity of the change in the angle of curvature (or vice versa);

6) by the magnitude of the intensity of the change in the angle of curvature, we determine the radii and compare them with the minimum permissible ones; we take the rate of decrease in the angle of curvature according to practice data;

7) we determine the maximum angle of inclination of the borehole and the projection of all sections of the borehole on the horizontal and vertical planes. If the angle of curvature of the hole is set, then we determine the value of the radius of curvature and the intensity of the angle of curvature;

8) based on the calculated data, we build the design profile of the borehole.

At the end of the profile calculation on millimeter paper, we build horizontal and vertical projections on the scales: horizontal projection - 1:200, 1:400 or 1:500; vertical projection - 1:1000 or 1:2000.

For the projected directional operational evaluation well № 707 on the Western Cheleken field a five-interval profile was selected (vertical section, section of the curvature parameter set, stabilization section, curvature set section, stabilization section).

The design data of the profile of the operational evaluation well №. 707 West Cheleken field shown in Table 1.

In the process of designing the well profile, the risk of collision of the hole of a new directional well with previously drilled wells was analyzed. To prevent the collision of boreholes, the Close Approach program of Schlumberger companies is used. For a more accurate assessment and prevention of the risk of crossing boreholes, the program module requires the following data from previously drilled wells:

- field diagrams of the bush;

- accurate data on the coordinates of neighboring wells and altitudes;

- the coordinate system used;

- complete information on inclinometry for all neighboring wells, in order to obtain a qualitative analysis of the risk of crossing the holes;

- if there is a choice, it is necessary to use Gyroscope measurements

- precise reference to the north;

- it is necessary to clarify by what type of azimuth the measurement was carried out (magnetic, geographical, cartographic);

- location of all adjacent wells.

In geometric analysis, the key parameter of convergence is the distance from the center to the center and is defined as the distance between the planned well and the neighboring well. Statistical analysis is the ratio of the distance from the center to the center between the wells and the sum of the radii (main semi-axes) of the ellipsoids of uncertainty around the analyzed well and neighboring wells, which are scanned at any given point.

Table 1.

Note	Hole depth (m)	Zenith angle, (º)	Azimuth grad, (º)	Vertical depth, (m)	Displacement (m)	North South (m)	East West (m)	Intensity (deg/ 30m)	Azimuth of the angle set (º)
Wellhead - SHL	***0,00***	***0,00***	***0,00***	***0,00***	***0,00***	***0,00***	***0,00***	***N/A***	***250M***
Marker MudLine	***9,00***	***0,00***	***250,00***	***9,00***	***0,00***	***0,00***	***0,00***	***0,00***	***250M***
Intermediate column №l - 13 3,8″ Casing Shoe	***800,00***	***0,00***	***250,00***	***800,00***	***0,00***	***0,00***	***0,00***	***0,00***	***250M***
The starting point of the angle set - KOR	***1650,00***	***0,00***	***250,00***	***1650,00***	***0,00***	***0,00***	***0,00***	***0***	***250M***
	1680,00	1,80	250,00	1680,00	0,47	-0,16	-044	1,80	250M
	1710,00	3,60	250,00	1709,96	1,88	-0,64	-1.77	1,80	250M
	1740,00	5,40	250,00	1739,87	4,22	-1,45	-3,98	1,80	HS
	1770,00	7,20	250,00	1769,68	7,50	-2,58	-7,08	1,80	HS
	1800,00	9,00	250,00	1799,38	11,71	-4,02	-11,05	1,80	HS
	1830,00	10,80	250,00	1828,94	16,85	-5,79	-15,89	1,80	HS
	1860,00	12,60	250,00	1858,31	22,91	-7,87	-21,61	1,80	HS
	1890,00	14,40	250,00	1887,48	29,89	-10,26	-28,19	1,80	HS
	1920,00	16,20	250,00	1916,42	37,77	-12,97	-35,63	1,80	HS
	19500,0	18,00	250,00	1945,09	46,56	-15,99	-43,92	1,80	HS
	1980,00	19,80	250,00	1973,47	56,24	-19,31	-53,05	1,80	HS
	2010,00	21,80	250,00	2001,53	66,80	-22,94	-63,01	1,80	HS
	2040,00	23,40	250,00	2029,25	78,24	-26,86	-73,80	1,80	HS
	2070,00	25,20	250,00	2056,59	90,54	-31,08	-85,40	1,80	HS
Angle Stabilization - EOC	***2100,00***	***27,00***	***250,00***	***2083,53***	***103,69***	***-35,60***	***-97,80***	***1,80***	***HS***
Intermediate column №2 -9 5,8″ Casing Shoe	***2118,49***	***27,00***	***250,00***	***2100,00***	***112,05***	***-38,47***	***-105,69***	***0,00***	***HS***
The starting point of the angle set - KOR	***2150,00***	***27,00***	***250,00***	***2128,08***	***126,30***	***-43,36***	***-119,13***	***0,00***	***28,73R***
	2160,00	27,48	250,57	2136,97	130,86	-44,91	-123,44	1,65	28,22R
	2190,00	28,95	252,19	2163,40	145,01	-49,43	-136,89	1,65	26,79R
	2220,00	30,43	253,66	2189,47	159,86	-53,79	-151,09	1,65	25,52R
	2250,00	31,93	255,00	2215,13	175,39	-57,98	-166,05	1,65	24,36 R
	2280,00	33,44	256,24	2240,38	191,59	-62,00	-181,74	1,65	23,32R

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JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

	2310,00 2340,00 2370,00	34,96 36,50 38,04	257,38 258,44 259,42	2265,19 2289,54 2313,42	208,45 225,94 244,07	-65,84 -69,51 -72,99	-198,16 -215,29 -233,12	1,65 1,65 1,65	22,38R 21,52R 20,74R
Angle Stabilization - EOC	***2388,64***	***39,00***	***260,00***	***2328,00***	***255,63***	***-75,07***	***-244,54***	***1,65***	***HS***
The roof of the formation	***2700,04***	***39,00***	***260,00***	***2570,00***	***450,86***	***-109,10***	***-437,53***	***0,00***	***HS***
Final depth - TD	***2764,37***	***39,00***	***260,00***	***2620,00***	***491,19***	***-116,13***	***-477,40***	***0,00***	

Schlumberger's indicators for the Close Approach program to determine the collision prevention of the borehole are as follows:

- if OSF>5 in addition to the minimum separation (MAS) > 80% of the allowable deviation from the ADP plan – Drilling is allowed;

- if 5> OSF>1.5 in addition to the minimum separation (MAS) > 80% of the allowable deviation from the ADP plan – Drilling is allowed;

- if 1.5> OSF>1.0 in addition to the minimum separation (MAS) > 80% of the allowable deviation from the ADP plan is a Risk zone (Minor risk zone). It is necessary to plug the neighboring well. Bring the measurement into the drilling well with a more accurate instrument or drill with a special resolution (exemption);

- if OSF <1.0 or minimum separation (MAS) <80% of the permissible deviation from the plan ADP – intersection (Major risk zone) stop drilling or drill with special permission (exemption).

According to the conclusion of the Schlumberger Close Approach program, the collision of the hole of the projected directional well №707 with the holes of previously drilled wells is low.

Schlumberger's conclusion on the Close Approach program to prevent the collision of the borehole №707 on the Western Cheleken field with the holes of previously drilled wells is shown in Table 2.

Table 2.

Adja-cent wells	Separation		Permissible deviation (m)	Separation coefficient (Sep. Fac.)	Depth (m)		Risk level			Status
	Distance (m)	Uncertainty			by the hole	verti-cally	War-ning	Low	High	
Cheleken-217 Surveys(DefSurvey)										**Fail Minor**
	187,26	186,67	177,26	N/A	0,00	0,00				
	185,64	148,08	129,54	4,99	1983,00	1976,00	OSF< 5.0			
	59,88	19,48	-0.48	1,49	2454,00	2378,79		OSF< 1.50		
	50,92	7,26	-14,33	1,17	2505,00	2418,00				
	51,13	6,89	-14,99	1,16	2514,00	2425,42				
	51,32	6,92	-15,03	1,16	2517,00	2427,76				
	66,77	21,60	-0,75	1,48	2580,00	2476,72		OSF> 1.50		
Cheleken-524 Surveys(DefSurvey)										**Fail Minor**
	89,77	89,17	79,77	N/A	0,00	0,00				
	247,38	197,32	172,53	4,98	2310,00	2265,19	OSF< 5.0			
	94,41	30,90	-0,57	1,49	2640,00	2523,34		OSF< 1.50		
	86,19	17,12	-17,17	1,25	2703,00	2572,30				

	86,49	16,74	-17,90	1,24	2715,00	2581,63				
	86,67	16,77	-17,94	1,24	2718,00	2583,96				
	94,88	25,22	-9,36	1,36	2764,37	2620,00				
Cheleken-429 Surveys(DefSurvey)										**Warning Alert**
	108,27	107,67	98,27	N/A	0,00	0,00				
	264,58	211,23	184,79	5,00	2475,00	2395,11	OSF< 5.0			
	223,36	153,25	118,44	3,20	2764,37	2620,00				

For all calculations of the risk of intersection (collision) of holes, the northern landmark is always used to measure the azimuth angle.

From a depth of 800 m, a hydrocarbon-based drilling mud of the Versadril system was used. The Versadril system is one of the best systems for drilling clays, where the stability of the hole is the main criterion. In addition, this system operates at high temperatures up to 180-190 °C and has more improved rheological properties. The "Versadril" system has a very low water output.

The purpose of directional drilling is to hit the final bottom of the well at a predetermined point in the productive formation. As a rule, it is set along the roof of the productive reservoir and is the center of the tolerance circle. If you get into this circle, the project task is considered completed. For various mining and geological conditions, the purpose of the well, its depth (vertically), the radius of the tolerance circle ranges from 15 - 60 m.

The project provides for the following purpose and task of the well;

The azimuth angle is 260° ± 10°, the zenith angle is 39°, the maximum change in the zenith angle degree / 10 m is 0.6°, the vertical depth of the roof of the productive layer is 2570 m. The offset from the vertical at the entrance of the roof of the productive reservoir is 450,86 ± 25 m .

When drilling a well, the maximum displacement of the bottom was 491.19 m with a magnetic azimuth of 260 °, the maximum zenith angle at a depth of 2764 m was equal to 39.0 °. As a result of the development of the productive facility, an inflow was received with a maximum total flow rate of 30 tons /day.

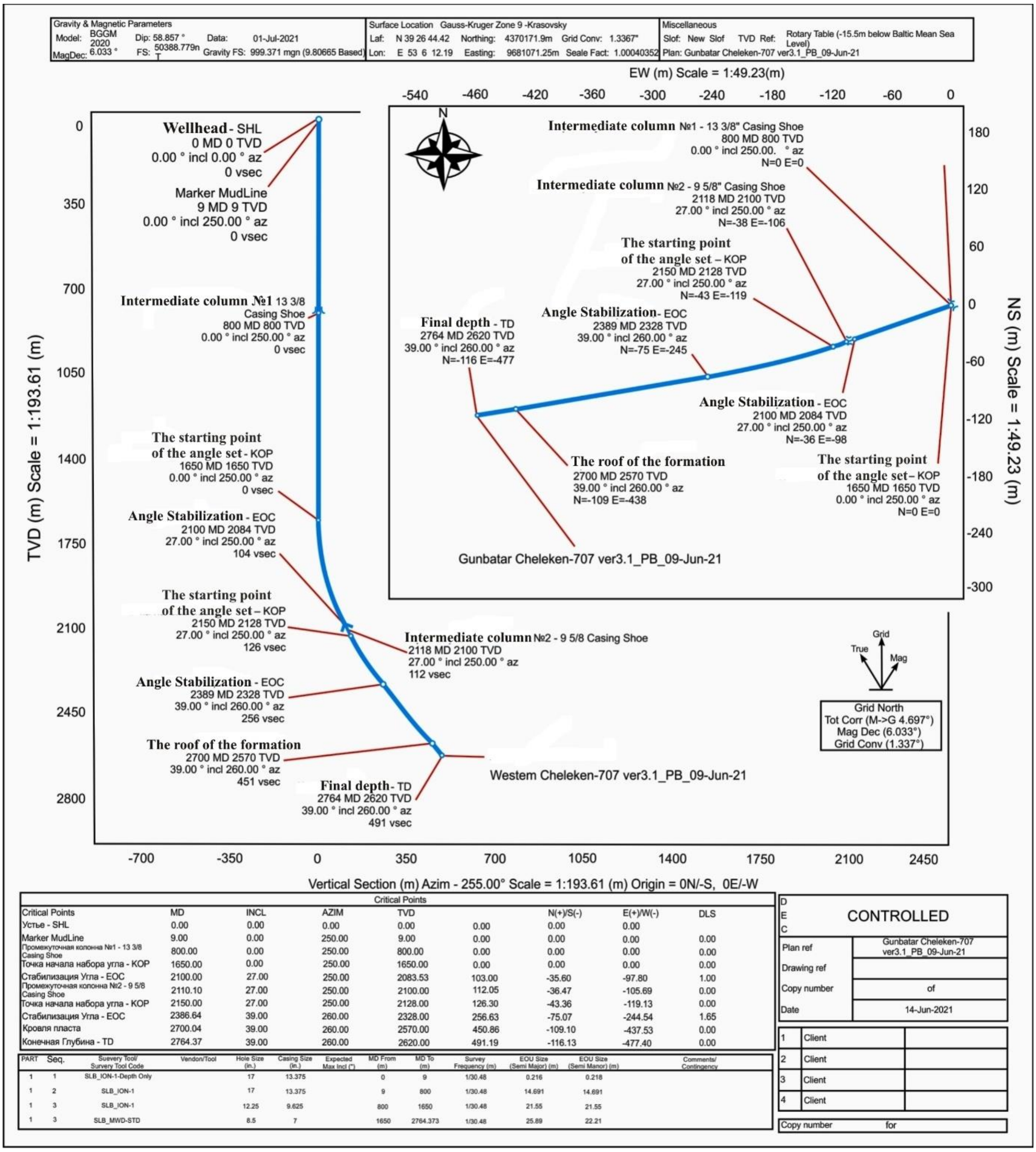

Figure 1. The profile of the hole of the directional operational evaluation well № 707 West Cheleken.

Directional production and evaluation well № 707 on the West Cheleken area has successfully fulfilled its goal, confirming the oil and gas potential of this section of the field without additional costs.

The profile of the hole of the directional operational evaluation well № 707 Western Cheleken is shown in figure.

Conclusions

1. The directional production and evaluation well has fully fulfilled its purpose and objective.

2. The use of methods and means to control the geometric parameters of the wellbore and the position of the deflecting device, as well as telemetry systems conducted the successful completion of the well.

3. Correct analysis of the trajectory of the holes of previously drilled wells prevented the risk of collision of the holes of wells.

4. The resulting inflow of the well proves the correct selection of the profile.

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