Nafta-Gaz 2023, no. 8, pp. 537–544, DOI: 10.18668/NG.2023.08.05

Method of sidetracking by opening two windows in the columns of different diameters

Metoda sidetrackingu oparta na wykonaniu dwóch okien w kolumnach rur o różnych średnicach

Famil A. Asadov[1], Nargiz R. Akhundova[2], Samad A. Rzazade[2], Shirin O. Bahshaliyeva[2]

[1] *State Oil Company of the Azerbaijan Republic (SOCAR)*
[2] *Azerbaijan State Oil and Industry University*

ABSTRACT: While drilling from a vertical shaft the orientation of the diverter is carried out with the help of a magnetometer, leaving an interval of 18 m from the casing. The length of the milled interval could be reduced if a gyroscopic compass is used to orient the BHA. The open borehole section is covered with a strong cement sheath. To avoid magnetic interference, the bridge is drilled down to a depth of 6 m above the bottom of the open interval. A disadvantage of the full casing section milling method is an increased requirement on the strength of the cement bridge for drilling, and the difficulty in finding the head of the lower casing section if it needs to be drilled through after the sidetrack. In many cases, the mechanical drilling rate is limited by the conditions for removing cuttings, and for a horizontal section, the problem of removing cuttings becomes even more complicated. The design of modern milling tools is meant to produce small swarf that does not form clusters and is easily removed from the hole. During milling, it is preferable to flush the well with polymer drilling muds rather than clay muds. Hydrocarbon-based muds are not recommended for milling at all. An alternative to milling the entire casing cross-section is to make windows in the casing. This requires the installation of an oriented whipstock and the milling of the window in several stages. After a whipstock is positioned in the required direction, the stud connecting it with a milling machine of the first stage is cut off. On this basis, the paper proposes a method of sidetracking.

Key words: sidetracking, bottomhole assembly (BHA), whipstock, drilling mud, casing.

STRESZCZENIE: Podczas wiercenia pionowego odwiertu orientację odchylacza przeprowadza się za pomocą magnetometru, pozostawiając niezarurowany interwał 18 m. Długość wyfrezowanego interwału mogłaby zostać zmniejszona, gdyby do orientacji BHA użyto kompasu żyroskopowego. Udostępniony odcinek odwiertu pokryty jest solidnym płaszczem cementowym. W celu uniknięcia zakłóceń magnetycznych płaszcz cementowy zwiercany jest do głębokości 6 m nad spodem otwartego interwału. Wadą metody frezowania całej sekcji obudowy są zwiększone wymagania co do wytrzymałości korka cementowego przy wierceniu oraz trudność w znalezieniu czoła dolnego odcinka rur okładzinowych w przypadku konieczności jej przewiercenia po wykonaniu sidetrackingu. W wielu przypadkach prędkość wiercenia mechanicznego jest ograniczona warunkami usuwania zwiercin, a dla odcinka poziomego problem usuwania zwiercin staje się jeszcze bardziej skomplikowany. Konstrukcja nowoczesnych narzędzi frezujących ma na celu wytwarzanie małych wiór, które nie tworzą skupisk i są łatwe do usunięcia z otworu. Podczas frezowania bardziej korzystne jest płukanie odwiertu płuczkami polimerowymi niż płuczkami ilastymi. Z kolei płuczki na bazie węglowodorów w ogóle nie są zalecane do frezowania. Alternatywą dla frezowania całego przekroju rur okładzinowych jest wykonanie w nich okien. Wymaga to zamontowania zorientowanego klina odchylającego i wyfrezowania okna w kilku etapach. Po ustawieniu klina odchylającego w wymaganym kierunku odcinany jest kołek łączący go z frezarką pierwszego stopnia. Na tej podstawie w artykule zaproponowano wykorzystanie metody sidetrackingu.

Słowa kluczowe: odchylenie trajektorii odwiertu, dolny zestaw przewodu wiertniczego (BHA), klin odchylający, płuczka wiertnicza, rury okładzinowe.

Introduction

Sidetracking is one of the most productive methods of increasing oil production in reservoirs with a long history of development and to continue operating wells that cannot be recovered by other means. Sidetracking allows to involve untapped layers and areas in production and provides access to difficult local accumulations of minerals, which cannot be reached by vertical drilling. An important advantage of the backfill technology is an increase in oil recovery, so it can be

Corresponding author: N. Akhundova, e-mail: *akhundova.nargiz92@gmail.com*

Article contributed to the Editor: 03.04.2023. Approved for publication: 21.07.2023.

used instead of compaction. The use of such works makes it possible to save money on field development.

The technology of sidetracking itself implies the use of different methods of work: it may be a cutting of part of the string or wedge drilling with a deviation. It is worth noting that the use of sidetracks is equally effective for all known types of fields, while the cost of the extracted products will be lower and the payback period of rework is within 2 years or faster.

To increase wellbore length, wells with multiple horizontal deviations can be used. Sidetracking can also be combined with hydraulic fracturing, flattened wells, and other technologies to increase field development efficiency and lower operating costs.

The goal of the work

There are a total of two techniques that are used in sidetracking for wells that have not been developed for a long time: cutting part of the string and wedge drilling. The first type also includes the construction of wells with the withdrawal of the uncemented string and the creation of a full-size main borehole. The classic solution is to cut out a section of the oil string, i.e. the section with the desired length, thus it becomes possible to remove the magnetometer sensors of telemetry equipment used to adjust the borehole trajectory from the magnetic mass. The method implies a significant loss of time:

- the chance that a section will be cut in one descent is extremely small, and a regular change of the cutter will be required;
- the technology requires the installation of an additional bridge element, on which the main cement bridge is built later on;
- the procedure of working up the chute and drilling the shaft takes quite a long time since tools with a small diameter are used;
- a problem with sidetracking, such as difficulty in penetrating the bit at a high zenith angle, is possible: the operation of the pipe cutter contributes a lot of wear and increases the risk of breakage.

Since most of today's wells are slanted and the point of penetration is determined on a curved section, the azimuth can be calculated in advance. For this reason, it is not advisable to cut a large piece of string, since the length should be such as to allow the drill string to exit. Thus, the length of the cutout piece varies between 6–10 meters, and the exact figure depends on the pipe diameter and some design factors (Zeynalov, 2007).

In addition to the difficulties mentioned above, there are difficulties in drilling lateral wells such as a high degree of watercut during rework: a significant percentage of such wells begin to fill with formation water, the content of which could not have been predicted in advance. Also, some wells have a rather low flow rate, and lateral drilling is not able to increase productivity. A combination of methods (hydraulic fracturing, and other methods to increase productivity) may be considered more effective, but it is time-consuming and costly.

Performance of work

Today, the development of technologies and equipment is required to create several wellbores for one casing-type well. The problem of cementing well liners is also considered quite acute since annulus gaps are small in size. Contemporary researchers are making attempts to create reamers for hard formations and packers for small liners, and there is a chance that the problems will be solved with positive results from these works.

Among modern methods to develop oil and gas fields, such a solution as drilling lateral wellbores plays a big role. Their use makes it possible to solve a wide range of problems related to exploration works in the field, production from hard-to-reach places, current and overhaul repair, as well as workover of wells after a long period of extraction of mineral resources. Sidetracking technology involves several ways of carrying out the work, which are chosen based on the geological characteristics of deposits and financial and economic opportunities (Iskenderov and Ibrahimov, 2015).

For this process, special cutting tools, wedge-type deflectors, reamers, disconnecting devices, and other equipment are used. Construction of lateral branches is possible from strings with diameters from 114 mm to 245 mm. Nowadays this method is one of the best options to repair abandoned wells and increase the productivity of marginal oil and gas fields (Aliyev, 1985)

Sidetracking operations are carried out using a roller cone, cutter, and cutting bits equipped with tungsten carbide hardware, diamond and combination drill bits for continuous drilling, and bicentric bits for step-out. Turbine, electric, and screw motors are also used in the process, scrapers for cleaning the walls of the casing, cutting tools for casing hole processing, wedge deflectors for new cuttings, and various types of milling cutters.

The main advantage, which provides the technology of drilling lateral wells, is reducing the cost of machinery and consumables. In addition, these works allow you to minimize the negative impact on the environment. During the work, one does not need to withdraw territory for the arrangement of wells, as in the case of drilling a vertical shaft, and it requires minimum materials. The process of drilling itself is carried out with mobile equipment (Azar et al., 2007; Iskenderov, 2014).

The price of such works is much lower than the cost of creating a new vertical well. According to calculations, the construction of 150 sidetracks allows getting more than half a million tons of useful substances already in 3 years after the start of their work. The main peculiarity of sidetracking is low speed (3–5 m/h) and low penetration rate per drill bit. The ROP is 15–20 m per day, which is important to take into account when scheduling the work.

However, in addition to the above problems arising during sidetracking, there is another problem, which is the cutting of two or three windows in the columns of different diameters, through which the sidetracking is carried out. This problem can and does arise when the part of the casing where the window for sidetracking was to be opened is in an emergency condition (Gimatudinov, 2014).

This situation occurred when drilling wells in the water area of the Caspian Sea of the Bulla-Sea field. To solve this problem, a new approach for sidetracking was developed jointly with SOCAR (with the support of Halliburton, Baker Hughes).

Below there is a description of the problems and their solution necessary for sidetracking.

The approach of sidetracking through two casing strings may be considered the new approach (for Azerbaijan) for sidetracking.

Table 1. Geological data

Tabela 1. Dane geologiczne

Stratigraphic section [m]	
IV sediments	50–500
Abşeron section	500–1700
Aqcagil section	1700–1750
MQ	1750–5900
V horizon	4850–4980
VII horizon	5330–5450
VIII horizon	5800–5850
QD entrance	5850–5900

Thus, well No. 126 drilled from platform No. 122, located in the Bulla-sea field and designated for the development of pay zone VIII horizon in the northeastern flank of the structure of the second tectonic block.

Initially, based on geological and technical data, the project for drilling well #126 was developed. Initial data and the project itself in a brief form are presented in Table 1–3 and Figure 1.

Drilling to a depth of 4964 m, measurements (zenith, azimuth angles, and deviations) were carried out using the MWD system. This allowed to establish the borehole deviation A = 1001 m, the zenith angle α was 20° and azimuth φ = 170°, and the remaining section to a depth of 5750 m was drilled vertically.

While drilling at the inlet to the VII horizon at a depth of 5348 m at a mud density of 1.70 g/cm^3, a sinking occurred in the borehole (Figure 2). The tool was raised to a depth of 4697 m, up to the shoe of the previous string. As absorption occurred

Table 3. The density of drilling mud depending on the depth of the well

Tabela 3. Gęstość płuczki wiertniczej w zależności od głębokości odwiertu

Depth [m]	Density [q/sm^3]
0–700	1.25–1.30
700–120	1.35–1.40
1200–1500	1.65–1.70
1500–1700	1.75–1.80
1700–2500	1.80–1.85
2500–2800	1.85–1.90
2800–3200	2.00–2.05
3200–3800	2.05–2.10
3800–4800	2.10–2.15
4800–5480	1.68–1.73
5480–5900	2.10–2.15

Table 2. Structure of wellbore

Tabela 2. Konstrukcja otworu wiertniczego

Structure	Diameter [mm]	Depth [m]	Rise height of cement [m]
Mud line	820.0	70	Vurulma
Conductor	720.0	250	250
Surface conductor	609.6	1200	1200
I Intermediate casing	473.1	2800	2000
II Intermediate casing	339.7	4800	3500
III Intermediate casing	244.5	5480	4000
Production casing	168.3 (1000 m) × 177.8 (4900 m)	5900	3500
Backup option			
"Suspender" belt	558.8	1700–1000	700
"Suspender" belt	193.7	5800–5280	520
Production casing	139.7 (700 m) × 177.8 (5200 m)	5900	3500

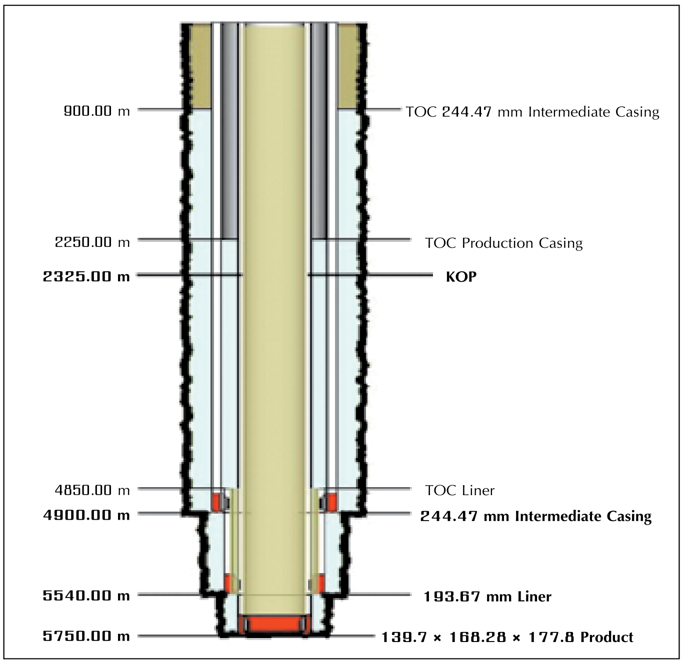


Figure 1. Construction of well

Rysunek 1. Budowa otworu wiertniczego

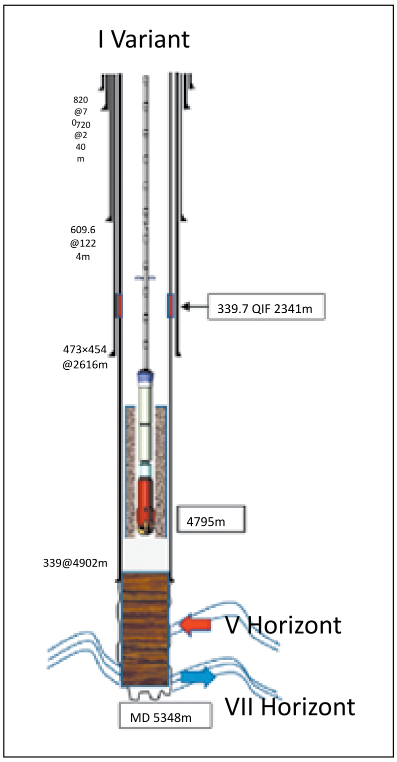


Figure 2. Construction of the lower part of the investigated well during its convection

Rysunek 2. Budowa dolnej części badanego otworu wiertniczego podczas konwekcji

in the borehole, the tool was regularly filled with drilling fluid to the shoe of the previous string as it was lifted. At a depth of 4697 m, the tool remained stationary for nearly 2 hours during mud preparation (Rzayev et al., 2010; Asadov et al., 2015).

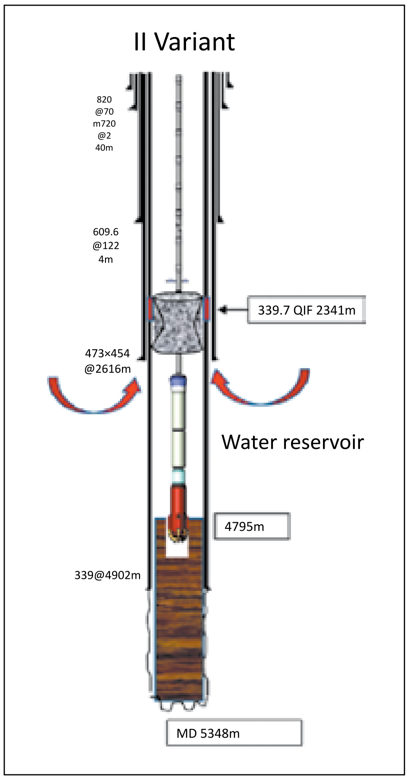


Figure 3. Construction of the lower part of drilled well

Rysunek 3. Budowa dolnej części otworu wiertniczego

When the tool was lifted to the wellhead at this point, a sticking motion occurred. Despite various efforts to free the tool, it failed, so the well had to be left for temporary preservation. Initially, cement bridges were installed at 3 intervals (90–190 m, 886–990 m, 2230–2363 m) in order to conserve the well.

After correcting documents, the decision was made to drill the sidetrack from the depth of 2253 m through two casing strings (339.7 m and 454 m) and bring it to the design depth (Figure 3). SOCAR, Baker Hughes, and Halliburton participated in the design of the second borehole as well as its piloting.

First, they worked out the well design starting from the starting point, set the azimuth the second hole would be oriented in, and calculated the profile of the new well and BHA to implement it (Figure 4, Table 4).

In fact, the well was drilled to a depth of 4894 m.

A Wipstock had to be installed for the second hole to be drilled. This operation was performed according to the method offered by Baker Hughes, and their equipment (BHA) was used (Figure 5 and Table 5). The following BHAs were used to cut the second hole.

The direction selection (azimuth) of the Drill Bit installation (its slant) has been set according to Table 6 on the third line. If the side guide does not indicate the correct direction, you must slowly rotate the drill string 90° to the right (Figure 6).

To warp and lower the anchor, the following steps must be applied:

Table 4. Calculated design profile

Tabela 4. Obliczony profil konstrukcyjny

Cutting depth [m]	Drilling progress [m]	Project depth [m]	Horizon	Density of drilling fluid [q/sm³]	Window		Wellhead	
					azimuth	Deviation [m]	azimuth	Deviation [m]
2325	3425	5750	UKS	1.80–2.15	196	656	183	900

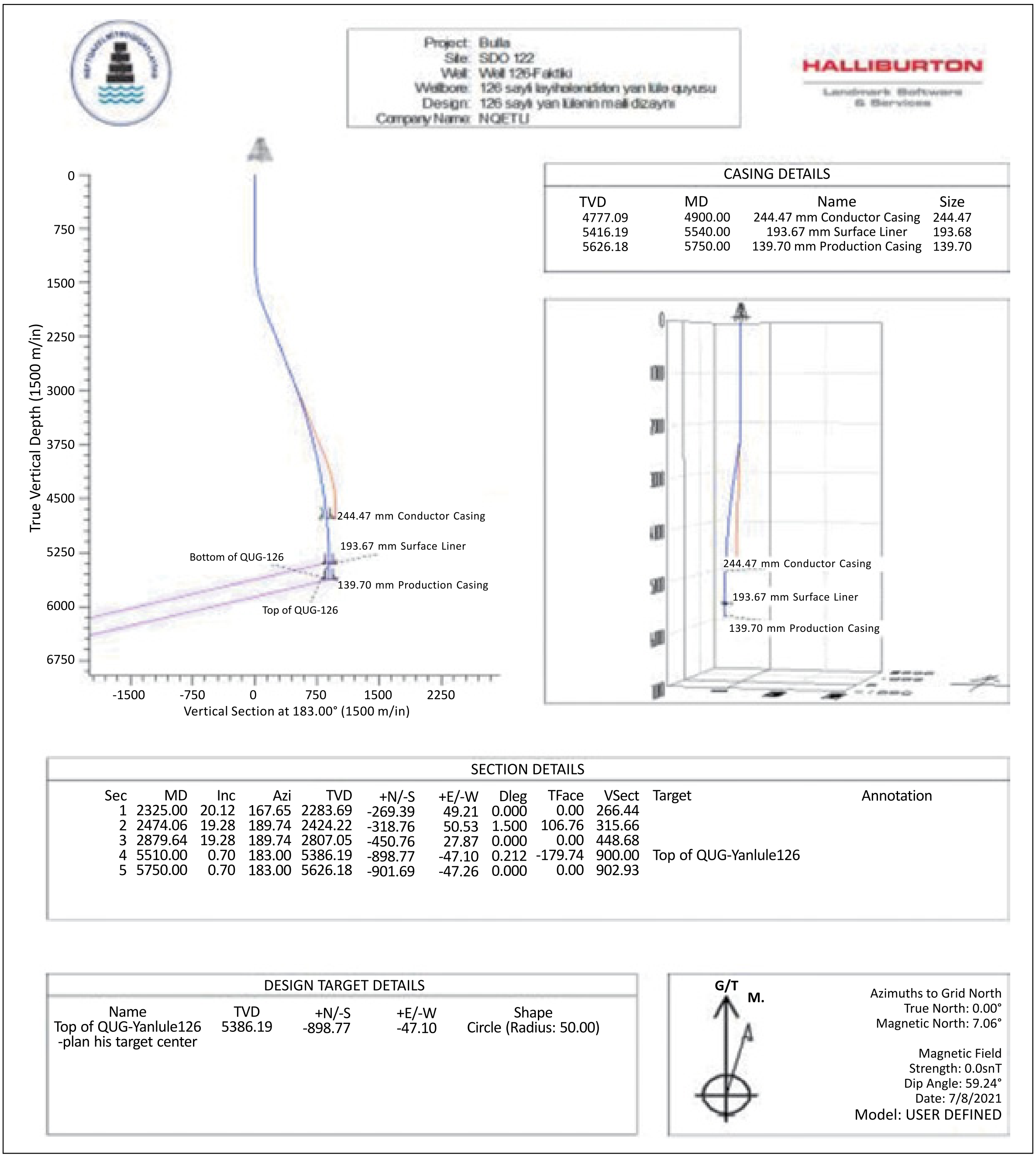


Figure 4. Calculated design profile

Rysunek 4. Obliczony profil konstrukcyjny

- You must increase the pump capacity to break the bolt (up to 450 gallons per minute);
- After reaching the target flow rate (450 gpm), cycle for 3 to 5 minutes to break the bolts;
- Once the system has stabilized, begin slowly reducing the pump rate to 330 gpm, then immediately stop the pumps and relieve the pressure in the drill pipe. This time the valve will be closed;

Table 5. Dimensions of the BHA and their place of installation
Tabela 5. Wymiary BHA i miejsce ich instalacji

Elements of BHA	Outer diameter [mm]	Length [m]	Range
Wedge – reverse	190.0	3.950	3–117
Start – window miller	273.0	1.123	3–121
Low milling cutter	297.3	0.805	3–133
Upper milling cutter	311.7	0.812	3–171
Conductor	203.0	0.475	3–171
Drilling well	127.0	9.140	3–147
Short rubber tube	127.0	3.000	3–147
Drilling well	127.0	2308.700	3–147
Total		2328.000	

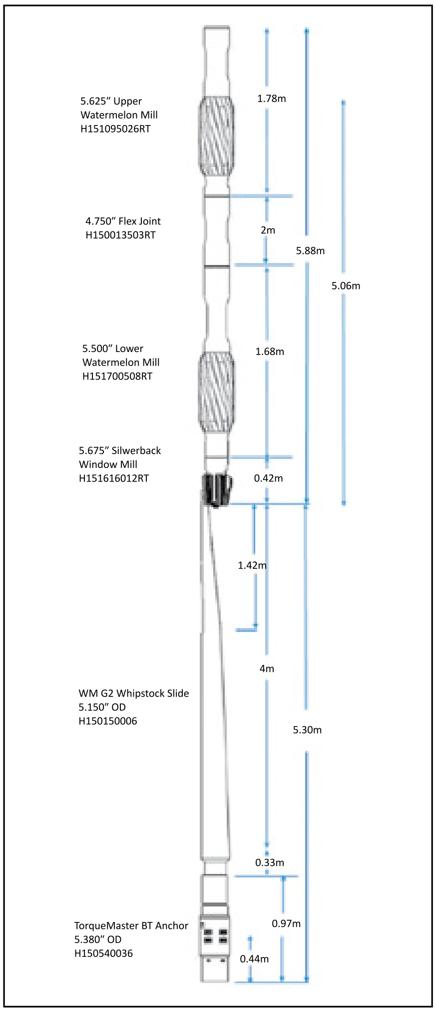


Figure 5. Bottomhole assembly (BHA)
Rysunek 5. Dolny zestaw przewodu wiertniczego (BHA)

- Slowly start the pumps to make sure that the system is now closed and holding pressure. If the pressure does not increase, retest by 15% more than the pump capacity when the valve is closed;
- Slowly increase pressure to 1600 psi in 500 psi increments to load the anchor and hold for 1 minute. Release the pressure;
- Weigh the anchor at 5,000 pounds to check the fit of the anchor. Add 5–10 pounds of tool weight and verify that the anchor does not move. If the test is negative, repeat the following steps;
- Gradually increase the shear value by adding another 10%, the pressure should not exceed 3250 pounds per square inch;
- If it still does not fit, lift the tool and replace it with a new one;
- Increase the pressure to 3250 psi to break the tear disk on the window mill (there may be a +/–20% difference in the final value of the tear disk);
- After installing the anchor, break off the shear bolt of the breaker wedge by loosening the tool to 60.000 pounds (27 tons). If you are not sure if the bolt is broken, repeat the previous process by applying an additional 10.000 pounds (4.5 tons) of pressure to the tool;
- Once you are sure that the bolt is broken, raise the tool +/–5 m above the deflector. After the mortar is fully circulated in the borehole, begin the window milling operation in the sequence shown in Table 7.

Cutter load and torque limit should not be applied to the tool at the same time. If the milling load on the cutter while milling the window is close to the manufacturer's limit, the torque may be up to 50% of the maximum limit.

The sequence of operations when opening a window:

1. The mortar velocity in the intertube space was maintained at 60–75 m/min;
2. The minimum dynamic shear stress of the scrap metal cleaning solution released during shredding was 60 lb/100 ft^2;
3. During operation, a magnet was placed on the chute line, which was regularly cleaned of accumulated scrap metal. The total weight of metal collected was approximately 470 kg;
4. After the window is completely open, it should be expanded accordingly and a drill of +/–9 meters should be made in the open barrel. The expansion operation should be continued

Table 6. Data of the oriented whipstock
Tabela 6. Dane zorientowanego klina odchylającego

Well barrel zenith angle	Tolt angle to the left from the top of whipstock's wellbore		Top of whipstock's wellbore angle of rotation to the right	
	removable	one time	removable	one time
0–3°	In any direction			
3–30°	0–60°	0–75°	0–60°	0–75°
31–60°	25–60°	25–75°	10–60°	10–75°
61–90°	25–45°	25–60°	10–45°	10–60°

until the tool is free to pass through the window with and without circulation;
5. After reaching +/–2342 meters, the screens should be flushed until completely clean and the mortar parameters adjusted;
6. Lift the tool and disassemble the BHA.

The opening of the window was successfully carried out by this bell in the interval 2253–2262 m. Thus, controlling the set torque and speed in accordance with the work plan, the operation window opening was completed (Mustafayev and Aliyeva, 2015; Zuplikarov et al., 2015).

A total of 3 raisers were used to open the window between 2253–2262 m for a total of 15 hours. The opening of the hole was made with the risers, the maximum size of which corresponded to the inner size of 339.7 mm of the column and was 311 mm.

All of this allowed us to successfully drill the hole to our intended depth with only minor modifications. The drilling process in this case continues.

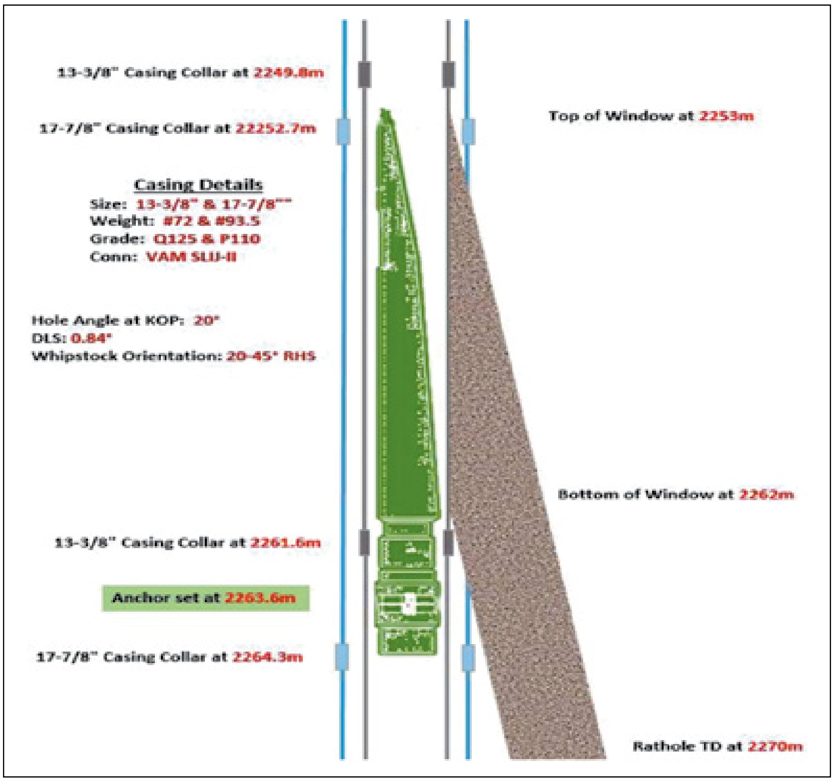


Figure 6. Well design after drilling the second wellbore
Rysunek 6. Konstrukcja otworu wiertniczego po odwierceniu drugiego odwiertu

Table 7. Technological data of the sidetracking
Tabela 7. Dane technologiczne sidetrackingu

Size of wellbore	Depth [feet]	Speed of drilling [fut/hour]	Number of revolution rotor [rotation/min]	The load on the mill [klb]	Maximum load on the mill
13 3/8"	beginning 2	1–2	70–110	2–4	55
	2–17	2–5		2–12	
	17–18 main point	1–2		2–10	
	18–29.5	2–5		2–12	
	open hole	–		2–15	55

Conclusion

Sidetracking technology is one of the most productive methods that allows you to increase the production of oil products in deposits with a long history of development and continue to operate wells that cannot be restored in other ways. The creation of sidetracks allows the involvement of unused layers and areas in production, and provides access to difficult local accumulations of minerals that cannot be obtained by vertical drilling. For the first time, we successfully drilled a window with a milling set of two windows (339.7 × 454.025 mm) in well #126 in the Bulla-sea offshore field, Azerbaijan, from interval 2252–2263 m.

Acknowledgments

The authors gratefully acknowledge the discussion with Associate Professor, Candidate of Technical Sciences R.S. Ibrahimov to bring this manuscript in the present form.

References

Aliyev N.N., 1985. Experience in drilling two holes in response to accidents in a deep well. *Directional Drilling Theory and Practice*, 73–76.

Asadov F.A., Huseynov H.Q., Aliyeva L.N., 2015. Investigating the possibility of moving the azimuth given in the drilling process towards the productive layer in a stable direction in the drilling side pipes. *SRI "Oil Gas Geotechnological problems and Chemistry" Scientific Articles*, 16: 92–97.

Azar J.J., Robello S.Q., 2007. Drilling Engineering. *PennWell Corporation, Tulsa*, 411–425.

Gimatudinov Sh.K., 2014. Development and operation of oil, gas condensate fields. *Nedra*, 1: 136.

Iskenderov D.A., 2014. A handbook for oil and gas extraction workers. *Mars Print, Baku*, 122–130.

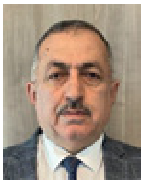
Iskenderov D.A., Ibrahimov Y.A., 2015. Overhaul of oil and gas wells. *Mars Print, Baku*, 139–147.

Mustafayev S.D., Aliyeva M.Q., 2015. Influence of Drilling Well Profile on the Solution of Theoretical Problems of Oil Field Development. *ANH*, 9: 14–17.

Rzayev Q.A., Mammadov A.Y., Beylerova G.A., Mahmudova V.Z., 2010. Improvement of drilling technology of sidebore wells. *SRI "Oil Gas Geotechnological problems and Chemistry" Scientific Articles*, 11, 71–77.

Zeynalov R.M., 2007. Complications that may occur during the drilling of deep wells in the Azerbaijani sector of the Caspian Sea and measures to combat them. *Azerbaijan Oil Industry*, 6: 35–37.

Zuplikarov D.A., Plutta S.O., Petrenko M.A., Dunayev A.S., 2015. Drilling bits lecture. *ROGTEC*, 40: 38–58.



Famil Asad ASADOV, M.Sc.
Deputy Head of Drilling Department at the State Oil Company of the Azerbaijan Republic (SOCAR)
121 Heydar Aliyev Ave, Baku, Azerbaijan
E-mail: *famil.asadov@socar.az*

Nargiz Rovshan AKHUNDOVA, M.Sc.
Assistant Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and Industry University
Khagani str. 31, Baku, Azerbaijan
E-mail: *akhundova.nargiz92@gmail.com*

Samed Ali-İskender RZAZADE, Sc.D. Candidate
Associate Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and Industry University
70 Azadliq Ave., Baku, Azerbaijan
E-mail: *sameddrilling7@gmail.com*

Shirin Oktay BAHSHALIYEVA, Ph.D. Candidate
Assistant Professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and Industry University
16/21 Azadliq Ave, Baku, Azerbaijan
E-mail: *bahshaliyeva@mail.ru*