International Journal of Energy
ISSN: 2957-9473 | Vol. 3, No. 2, 2023

Practice and Analysis of Plugging Horizontal Wells in the Chang-7 Section of the Dingbian Qingyang Area of the Ordos Basin

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Abstract: Lost circulation can cause formation pollution and pressure imbalance, leading to various accidents in drilling engineering. It is necessary to have clarify the mechanism of drilling fluid leakage during the drilling process and the nature and condition of the leakage Analyze the different types of leakage in the Chang7 section of typical leakage wells in the Dingbian and Qingyang areas of the Yishan Slope in the Ordos Basin of Changqing Oilfield The research results indicate that: Permeable leakage is Leakage type with low leakage volume and low leakage rate, Plugging while drilling can be used until completion of the well.Large loss of reactivity requires multiple pumps of a large amount of plugging slurry to stop the leak, the required plugging slurry equivalent is closeLeakage caused by improper cementing due to engineering factors cannot be stopped by pumping the plugging slurry, This type of leakage situation requires cementing to achieve the goal of preventing leakage, And this kind of leakage will occur repeatedly. The leakage situation will evolve from initial permeable leakage to large-scale leakage The research results indicate the basic conditions for the occurrence of well leakage, combined with specific measures for plugging, Experience in providing leakage prevention and plugging techniques.

Keywords: Horizontal Well Leakage; Plugging Measures; Case Analysis.

1. Geological Overview

The Ordos Basin can be divided into six primary structural units based on its structural morphology: Yimeng Uplift, Weibei Uplift, Western Margin Thrust Belt, Shanxi West Fold Belt, Tianhuan Depression, and Yishan Slope. The Yishan Slope covers a vast area within the Ordos Basin. The development of the strata in this area is relatively gentle, mainly tilting towards the west, with a dip angle amplitude of less than 1 degree. The Yishan Slope mainly develops nose shaped structures and some small faults[1-2].The research block is located in the southwestern part of the Yishan Slope in the Ordos Basin, with a simple regional structure and no major fault development. The strata are relatively flat, mainly located in the 7th member of the Triassic Yanchang Formation. It is a large set of clastic rock deposits in the delta front of the inland lake basin during the extension period, with multiple layers of tuffaceous mudstone, dark mudstone, silty mudstone, and dark gray shale developed. The reservoir lithology is dense[3].The research area is shown in Fig 1



Fig 1. Study area

2. Types of Leakage and Influencing Factors

2.1. Leakage Type

2.1.1. Permeable Leakage

Permeability leakage often occurs in formations with poor cementation and good permeability. According to the actual situation, the leakage rate is generally less than 5m3/h, and the leakage rate increases proportionally to the bottom hole pressure[4]. Generally, the return amount is less than the injection amount when the well is not cemented.

2.1.2. Fractured Leakage

There are two main types of fissured leakage: natural fractures and induced fractures. The length of cracks spans from centimeters to kilometers, with different forms of crack development and strong heterogeneity. The cracks open or close with changes in static fluid column pressure. When the liquid column pressure is greater than the formation pore pressure, the fracture opens and the wellbore leaks. The factors affecting this type of leakage are complex, including formation connectivity, fracture development degree, and changes in bottom hole pressure, which require comprehensive analysis from all aspects [5-6].

2.1.3. Cracks - Porous Leakage

There are two main types of crevice hole leakage: crack hole type and hole type. This type of formation has strong stress sensitivity, developed fractures and pores, and strong randomness in distribution, with complex connectivity. The occurrence of leakage wells in this type of bottom layer can easily damage the stress state of the formation, release stress from the rock, and lead to the generation of new cracks. If the pressure at the bottom of the well is too high, it can cause cracks to open and continue to extend, connecting with surrounding holes and causing leakage problems. This type of leakage has fast speed, large amount of leakage, and high

difficulty in plugging. The classification of leakage levels is shown in Table 1.

Table 1. Leakage level classification

Leakage type	Velocity(m^3/h)	Analysis of Formation Characteristics and Leakage Situation
Seepage Leakage	0.1-1.5	permeable formation
Medium leakage	1.5-15	Porous or fractured formations; Formation with smaller natural or induced fractures
Large leakage	15-80	Medium natural cracks or medium induced cracks
Reflexive leakage	>80	Large natural cracks, karst caves, or large induced cracks

3. Construction Measures/Case Analysis of Leakage Stopping Construction

Taking the Horizontal Well Leakage at Yulin Dingbian and Qingyang on the Yishan Slope of the Ordos Basin as an example.

3.1. Regional Overview

This block is located on the Yishan Slope of the Ordos Basin, with a simple regional structure and no major fault development. The strata are relatively flat. The Yanchang Formation 7 of the Triassic system was a set of large intracontinental lacustrine delta front clastic rock deposits during the extension period, and the reservoir lithology is dense.

(1) K1 marker layer (Zhangjiatan shale)

The Zhangjiatan shale is one of the main marker layers in the basin, characterized by a set of thick gray black shale, carbonaceous shale, and tuffaceous mudstone interbedded layers, with a wide distribution range and stable development.

(2) K2 marker layer

The K2 marker layer is also one of the main marker layers for stratigraphic correlation in the Yanchang Formation of the basin. The lithology is grayish black mudstone, argillaceous siltstone, and interbedded fine sandstone with thin layers of tuff, located at the bottom of the Chang6 oil layer group

Table 2. Flag layer and feature table

Marker Bed	Depth	Lithological Characteristics	Logging Curve Characteristics
Tuffaceous mudstone	Long 6 bottoms (Auxiliary marker layer)	Developing multiple layers of tuffaceous mudstone (porphyry)	High gamma, high acoustic time difference, low resistivity
Zhangjiatan Shale	Long 7 Bottom (Main marker layer)	Dark mudstone, silty mudstone, dark gray mudstone	Acoustic time difference, high gamma, medium high resistance

3.2. Case Analysis

The well is located in Dingbian County, Yulin City, Shaanxi Province, with a structural location on the Yishan Slope of the Ordos Basin and a completed drilling horizon of the Chang 7 section.

Basic information of APX well: The completed drilling depth is 3959m, with a horizontal well and a drilling fluid density of 1.21-1.25g/cm^3. Drilling was started on September 22, 2021, completed on October 13, 2021, and completed on October 19, 2021, with a horizontal oil layer length of 1091.6m.

3.2.1. First Lost Circulation

On October 7, 2021, at 20:20, the well was drilled to a depth of 3119m (with a formation length of 7). During drilling, the drilling pressure suddenly decreased from 11 tons to 6 tons, and the pump pressure increased from 16Mpa to 20MPa. After removing the pump, the pump was lifted up and turned on. There was no mud returning from the mud outlet, and the liquid level in the circulation tank decreased significantly. The top of the single valve top pump was used, but there was no mud returning from the outlet; Grouting from the wellhead indicates that there is still no mud backflow at the outlet, indicating a leakage. A total of 15.79m^3 of mud was lost during this process.

3.2.2. Handling Measures

Table 3. Flag layer and feature table

Date	Time		Leakage Amount/m^3	Velocitym^3/h
October 7th	20:20		15.79	17.23
	21:15		10.13	3.29
	0:20			0.6
October 8th	1:10		0.5	1.49
	4:00		4.22	1.31
	7:00		3.92	0.82
Total	Time Consuming/h	11	Leakage/m^3	30.76

Starting at 21:15, while lifting and pouring mud from the wellhead, prepare a plugging slurry with a density of 1.18g/cm^3 and a viscosity of 62S. On October 7th at 23:50, the pump was started to pump in the plugging slurry (the outlet did not return during the lifting process, with a total of 8.42m^3 of slurry being lifted). The first time 18.5m^3 of plugging slurry was pumped in, but the outlet did not return when the plugging slurry was pumped in. Starting from 0:20 on October 8th, the replacement volume was 8m^3, and the outlet returned mud with a leakage rate of 0.6m^3/h; 1: After

10 rounds of static observation, the pump was started and circulated for observation. A total of 3.92 cubic meters of lost mud and a total of 30.76 cubic meters of lost mud were circulated until 4:00, and 18.5 cubic meters of lost mud were pumped in. Subsequently, while drilling, the leakage was plugged, and the mud consumption was normal, at 0.82m^3/h. The loss situation is shown in Table 3.

3.2.3. Second Lost Circulation

At 16:00 on October 12th, a well leakage occurred when drilling to a depth of 3750 meters, with a leakage rate of about 5-6 cubic meters per hour. 30 cubic meters of plugging slurry were used to plug the well while drilling, and at 17:20, the leakage rate was reduced to 4-5 cubic meters per hour. Another 30 cubic meters of plugging slurry were used to plug the well while drilling, with a leakage rate of 1-3 cubic meters per hour. Plugging while drilling until completion of drilling.

The well has lost a total of two times, with a total loss of 30.76 cubic meters. After the plugging agent was pumped in, the loss rate significantly decreased, with a small loss rate and a low loss amount. This type of leakage is mostly a permeable formation, mainly when the bridging particle size in the drilling fluid is not large enough to form a seal, or when there are no fine particles to complete the seal, resulting in this permeable leakage.

4. Factors Affecting the Occurrence of Well Leakage

4.1. Geologic Factor

There are natural fractures and karst caves in the formation, with good connectivity and high permeability, providing a natural channel for drilling and completion fluid leakage;

4.2. Mismatch of Drilling Fluid

The main reason is that the particle size of the sealing agent in the drilling fluid is smaller than the size of the formation fractures, which cannot effectively seal the leaking fractures in a timely manner, ultimately leading to well leakage. Or the drilling fluid density is too high, causing the pressure of the drilling fluid column to be greater than the formation fracture pressure, causing the original fractures of the formation to open or generate new fractures, forming new leakage channels.

4.3. Engineering Factors

Improper drilling engineering measures, such as too fast drilling speed or too strong pump operation, can cause downhole pressure to be excited, resulting in a bottomhole pressure greater than the formation fracture pressure or leakage pressure.

5. Summarize

Uncontrolled wellbore leakage can lead to serious production accidents and huge property losses, so more effective prevention and control measures should be taken.

1.Strengthen wellbore preparation:

To ensure smooth casing operation and sealing quality, it is necessary to clear the well before running the casing, and make records of obstacles and blockages. Short tripping and tripping should be carried out in the blocked section until it is unobstructed. To ensure the stability of the wellbore, it is necessary to wash the well with large displacement and perform segmented circulation. Similarly, when the drilling tool is lowered to the bottom of the well, it still needs to be fully circulated and no rock debris returns from the shale shaker before tripping out. During the process of casing installation, it is necessary to prevent pressure stimulation and formation leakage. After the casing installation is completed, drilling fluid circulation should be carried out first to confirm that there is no leakage or foreign object during the circulation period. Construction can only be carried out after ensuring that the wellbore is stable and meets the cementing requirements.

2.Application of two-stage cementing technology:

The application of two-stage cementing technology can effectively reduce the pressure of the annular liquid column, avoiding leakage caused by high cement slurry column pressure during the cementing process. It has a high adaptability to dealing with formation leakage and insufficient cement return height.

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