SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2023 **Issue:** 03 **Volume:** 119

Published: 03.03.2023 http://T-Science.org

Issue Article

Annaguly Rejepovich Deryaev
Scientific Research Institute of Natural Gas of the State Concern „Turkmengas"
Candidate of Technical Sciences, Senior Researcher,
Ashgabat, Turkmenistan
annagulyderyayew@gmail.com

DESIGN OF THE INCLINED-DIRECTIONAL WELL STRUCTURE

Abstract: *The article discusses the design of the design of an inclined directional operational evaluation well in order to restore oil production from an inactive field in the coastal zones of the coastal waters of the Caspian Sea. Materials of previously drilled wells and standard calculations were used to design the well structure.*

This work can be used to select the design for the development of fields in difficult-to-digest marine shallow waters, for trouble-free conduct of the drilling process in difficult mining and geological conditions at abnormally high reservoir pressures.

Key words: *wellhead, inter-column space, casing, oil and gas occurrence, preventer, conductor, grouting solution, well profile, logging, fastening zone.*

Language: *English*

Citation: Deryaev, A. R. (2023). Design of the inclined-directional well structure. *ISJ Theoretical & Applied Science, 03 (119),* 1-6.

Soi: http://s-o-i.org/1.1/TAS-03-119-1 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2023.03.119.1

Scopus ASCC: *2209.*

Introduction

The design of the well in terms of reliability, manufacturability and safety should ensure:

-maximum use of reservoir energy of productive horizons during operation due to the optimal design and diameter of the production column;

-the use of efficient equipment, optimal methods and modes of operation, maintenance of reservoir pressure, thermal effects and other methods of increasing oil and gas recovery of reservoirs;

-conditions for safe work without accidents and complications at all stages of well construction and operation;

-obtaining the necessary mining and geological information on the section being opened;

-compliance with the conditions for the protection of the subsoil and the environment, primarily due to the strength and durability of the well support, the tightness of the casing columns and the ring spaces overlapped by them, as well as the isolation of fluid–containing horizons from each other, permeable rocks and the day surface;

-maximum unification according to the standard sizes of casing pipes and borehole.

All casing columns, except for the shaft and elongated direction, coming to the surface, must be suspended at the wellhead and rigidly connected to previously lowered columns using special devices - column heads. These devices must ensure the strapping of the casing strings and prevent unloading before suspension.

The binding of the wellhead should provide:

1. For the conductor:

a) the landing of the column head of the subsequent intermediate column;

b) installation of anti-blowout equipment;

c) the presence of at least 0.3 m of free part at the wellhead for the installation of devices for forced sealing of the wellhead with open gushing.

2. For intermediate and operational columns:

a) tension and suspension;

b) rigid and hermetic connections at the wellhead with a previously deflated column;

c) monitoring of the pressure in the inter-column space and leaks through the sealing unit;

d) the possibility of pumping liquid into the inter-column space;

e) installation of anti-blowout equipment;

f) installation of a perforating valve and fountain fittings.

The rate of descent of the casing string should not lead to hydraulic fracturing, as well as to crushing of the string or absorption of drilling mud.

It is forbidden to partially or completely unload the casing string at the bottom of the well. Unloading of the shank and sections on the face or on the previously lowered part of the casing is prohibited. The upper ends of the shank or casing section installed in the unsettled part of the hole should be located in the intervals of stable rocks that do not have caverns and gutter workings [1, 2].

When lowering the shank or section, the descent speed of the drill pipes should not exceed the descent speed of the casing pipes.

It is recommended to use deep suspension devices:

a) wedge-shaped - for shanks and sections weighing up to 0.5 MN when suspended in the cased part of the hole on an unworn section of the previous casing;

b) thrust - for suspension of shanks and sections of any mass in the cased part of the hole;

c) on cement stone - for suspension of columns of any mass in the unsettled or cased part of the hole with varying degrees of wear of the previous column, provided that there is no absorption and the lifting of the grouting solution is provided for the entire length of the shank or section.

The initial data for the design of the well structure are: the purpose of drilling and the purpose of the well, the design horizon and depth of the well, the diameter of the production column, reservoir pressures and hydraulic fracturing pressures of stratigraphic horizons, methods of completion of the well and its operation, the profile of the well and its characteristics, characteristics of rocks by strength.

When choosing a well design, the duration of drilling of each attachment zone, the intensity of wear of the conductor and intermediate casing strings, as well as the geological study of the drilling area are taken into account.

Directional production and evaluation well No.707 on the West Cheleken square 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. For the design of the well structure, data on reservoir pressures and temperatures of previously drilled wells were obtained [3].

The information of earlier accidents and gas and oil occurrences, as well as geophysical materials of the next neighboring wells, were collected and analyzed.

Well 262 (drilled in 1958) with a design depth of 2570 meters. Upon reaching a depth of 2168 m after logging with a density of 1.73 g/cm^3, the manifestation of a well with the output of drilling mud with a density of 1.73 g/cm^3 was detected. Attempts to close the preventer failed. The well went into open gushing.

Well 265 (drilled in 1958-1959) with a design depth of 2700 meters. At a drilling mud density of 1.75 g/cm^3, an operational column was lowered to a depth of 2562 meters. After perforation of the intervals 2508-2504; 2502-2493 meters during the descent of the tubing between the casing columns 6”x11”, a strong intercolonial manifestation of gas and water began. To eliminate the intercolonial manifestation using electrometry, the depth of the manifestation interval is determined. From a depth of 1437 meters, special holes were perforated in the production column and cement mortar was injected.

Well 429 (drilled in 1963) with a design depth of 2700 meters. With the correction of logging, it was drilled to an actual depth of 2743 meters. These intervals were drilled with the density of drilling mud: 2000-2082 meters 1.76 g/cm^3; 2082-2481 meters 1.80 g/cm^3; 2481-2743 meters 1.73-1.76 g/cm^3. No complications occurred during the drilling operations.

The depth of the conductor's descent was determined by the requirement of fastening the upper unstable deposits and isolation of the upper aquifers or absorbing horizons [4]. The conductor is equipped with anti-blowout fittings, therefore, the installation depth of the conductor's shoe was calculated from the condition of preventing hydraulic fracturing during the elimination of oil and gas occurrences according to the formula:

$$H = 100 \times P_{wellh.} + P_{wellh.1} / \gamma_{e.gr.} - \gamma_{res.f.} \qquad (1)$$

where $P_{wellh.}$ is the pressure at the wellhead with the preventer closed during oil and gas occurrences, MPa;

P_{wellh1} - additional pressure at the wellhead that occurs when cleaning the well from incoming reservoir fluids, MPa;

$\gamma_{e.gr}$ - drilling mud density equivalent to the hydraulic fracturing gradient at the depth of the conductor's shoe installation, g/cm^3;

$\gamma_{res.fl.}$ - the density of reservoir fluid in the borehole, g/cm^3.

To select the number of intermediate columns and the depth of their descent, a combined graph of changes in reservoir pressure, hydraulic fracturing pressure and hydrostatic pressure of the drilling mud column in the coordinates "depth-equivalent pressure gradient" was constructed.

The equivalent of the pressure gradient is the density of the liquid, the column of which in the well at the depth of determination creates a pressure equal to the reservoir or hydraulic fracturing pressure [5].

For drilling intervals, we find the values of the equivalents of reservoir pressure gradients according to the formula

$$P_{res.} = 0{,}01/H \qquad (2)$$

If there is no data on hydraulic fracturing pressures, then in exceptional cases it can be determined by the formula:

$$P_{hyd.fr.} = 0{,}0083H + 0{,}66P_{res.} \quad (3)$$

where H is the depth of determination of hydraulic fracturing pressure, m;

P_{res}-reservoir pressure at the depth of determination of hydraulic fracturing pressure, MPa.

Separately, for each interval, the hydraulic fracturing coefficient is found by the formula.

$$K_{hyd.fr.} = 0{,}01/H \quad (4)$$

In the intervals of occurrence of rocks in which a violation of the borehole zone of the well is possible, where the density of the drilling fluid is selected taking into account the rock pressure (pore pressure), instead of reservoir pressure, rock pressure can be plotted on the graph.

In the intervals of intensive absorption of drilling mud, instead of the hydraulic fracturing pressure, the pressure at which intensive absorption begins can be applied to the graph.

The zones of compatible drilling conditions are the zones of attachment of wells by casing strings, their number corresponds to the number of casing strings. [6,7,8]. The depth of the casing descent is assumed to be 10-20 m above the end of the fastening zone (zone of compatible conditions), but not higher than the depth of the beginning of the next zone of compatible conditions [9, 10].

The compatibility of drilling conditions is understood as a combination of them, when the created parameters of the technological processes of drilling the underlying interval of the well will not cause complications in the drilled overlying interval, if the latter is not fixed by the casing Based on calculations using the above formulas, hydrostatic pressure and hydraulic fracturing pressure are obtained, which are shown in Tables 1 and 2. Reservoir and pore pressure are obtained from indicators of neighboring wells, and hydraulic fracturing pressure is calculated using formulas 3 and 4.

Table 1.

Index of the stratigraphic unit	Interval, m		Pressure gradient						Temperature at the end of the interval ^0C
			reservoir		pore		hydraulic fracturing of rocks		
			kgf/cm^2 / m		kgf/cm^2 / m		kgf/cm^2 / m		
	from (top)	to (bottom)	from (top)	to (bottom)	from (top)	to (bottom)	from (top)	to (bottom)	
N^3_2 ar	0	200	0,100	0,120	0,100	0,120	0,149	0,162	30
N^3_2 ap-N^3_2 ak-N^2_2 kg	200	1000	0,120	0,132	0,120	0,132	0,162	0,170	41
N^2_2 kg	1000	1800	0,132	0,150	0,132	0,150	0,170	0,182	56
N^2_2 kg	1800	2000	0,150	0,155	0,150	0,155	0,182	0,185	61
N^2_2 kg	2000	2200	0,155	0,165	0,155	0,165	0,185	0,192	66
N^2_2 kg	2200	2650	0,165	0,173	0,165	0,173	0,192	0,213	72

Table 2.

Index of the stratigraphic unit	Interval, m		Pressure gradient				Temperature at the end of the interval, ^0C
			reservoir		hydrostatic pressure		
			kgf/cm^2 / m		kgf/cm^2 / m		
	from (top)	to (bottom)	from (top)	to (bottom)	from (top)	to (bottom)	
N^3_2 ap	0	200	0,100	0,120	0,120	0,140	30
N^3_2 ap-N^3_2 ак-N^2_2 кг	200	1000	0,120	0,132	0,140	0,147	41
N^2_2 кг	1000	1800	0,132	0,150	0,147	0,161	56
N^2_2 кг	1800	2000	0,150	0,155	0,161	0,168	61
N^2_2 кг	2000	2200	0,155	0,165	0,168	0,174	66
N^2_2 кг	2200	2650	0,165	0,173	0,174	0,181	72

Impact Factor:	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

The calculation of hydrostatic pressure is based on the calculation, according to the instructions "Safety rules in the oil and gas industry".

The hydrostatic pressure during the opening of gas-oil-water-saturated formations should be determined for the horizon with the maximum gradient of reservoir pressure in the range of compatible conditions [11, 12].

The minimum excess of the hydrostatic pressure of the drilling mud column relative to the roof of the formation being opened is shown in Table 3, taking into account the depth of the well and the anomaly of the reservoir pressure.

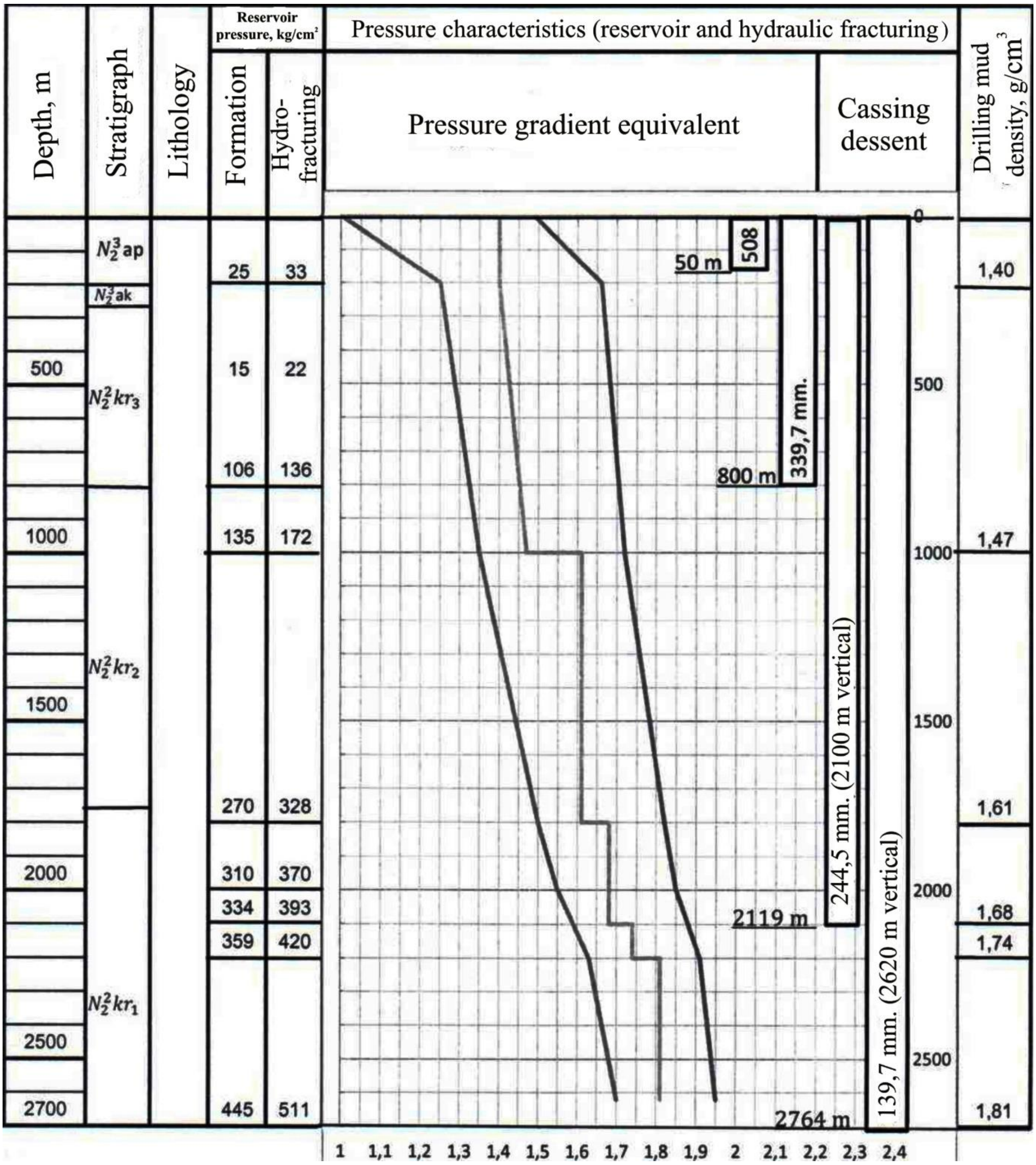

Figure 1. Combined graph of directional well No. 707 of the Western Cheleken field

** Note: According to the actual mining and geological conditions and the results of geophysical studies, the depth of the casing descent, as well as the density of the drilling mud may vary.*

Table 3.

Well depth (interval), m	Minimum excess of the hydrostatic pressure of the solution over the reservoir (repression), kgf/ cm^2	
	For oil-saturated reservoirs	For gas-bearing, gas-condensate formations and formations in unexplored intervals of exploration wells
0 -1000	10,0	15,0
1001 - 2500	15,0	20,0
2501 - 4500	20,0	22,5
4500 and more	25,0	27,0

Based on the calculation results obtained, a combined graph is constructed (Fig.1).

Based on the combined schedule, the following design was selected for overlapping incompatible sections for the directional production and evaluation well 707 on the Western Cheleken field, shown in Table 4.

Table 4.

№	**Name**	**Casing diameter (mm)**	**Descent depth (vertical/ hole) (m)**	**The reason for the attachment**
1.	Mining direction	708	7	Cement with butobeton. To eliminate the blurring of the wellhead.
2.	Elongated direction	508	50	For overlapping lightly cemented sandstones
3.	Conductor	339,7	800	For overlapping unstable layers of the horizons of Absheron, akchagyl and unstable water layers, as well as possible gas layers of the upper part of the horizon of the red-colored thickness
4.	Technical column	244,5	2100/2119	For overlapping in water and possibly gas layers of the middle, lower horizons of the red-colored strata, as well as for the purpose of controlling the anti-dew equipment in case of possible gas and oil water occurrences
5.	Operational column	139,7	2620/2764	For the exploitation of productive oil and gas horizons

The diameter of the casing strings is selected from the bottom up, starting from the production column.

Conclusions.

1. Analyzing complications, accidents, as well as geophysical materials of previously drilled wells and standard calculations carried out, the correct design of an obliquely directed operational evaluation well with difficult mining and geological conditions with abnormally high reservoir pressures was chosen.

2. Based on the calculations, the combined pressure graph made it possible for the casing strings to descend unhindered.

3. The design of the casing of the well in question is chosen correctly, this is proved by successful drilling of the well without complications to the design depth.

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