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National Technical University "Dnipro Polytechnic"
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EXPLANATORY NOTE

Qualification paper, degree bachelor
(bachelor, master)

student Omar Sayed Hassan Zeinhom
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title Technical project for drilling an exploration and production well in terms of Sakhalinsky oil and gas condensate deposit

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TASK
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title Technical project for drilling an exploration and production well at Sakhalinsky oil and gas condensate deposit

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Section	Content	Deadline
Technologic	Geological survey of drilling of the wells in terms of the gas-condensate deposit. Design of construction of drill holes, vibration method of drilling and drilling equipment.	07/07/2021
Labour Protection and Environment	Analysis of potential problems of the project concerning the possibilities of negative impact on the environment	07/16/2021

Task issued _____ O.A. Pashchenko
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ABSTRACT

Diploma project: 71 pages, 3 figures, 12 tables, 15 references.

The object of research is the construction of a well in terms of Sakhalinsky deposit with the development of effective methods for well development.

The objective of the paper is to develop a project for drilling a well in terms of Sakhalinsky deposit.

Research tools are literature analysis and theoretical research.

The paper is compiled in accordance with the requirements of the guidelines. It contains information about the drilling area, geological structure and characteristics of productive horizons. Also, in the design part, issues of well construction are resolved: design of the well structure, selection of equipment for a drilling rig, rock cutting tools, drilling and cementing technology. A description of possible accidents and complications and their prevention is given. The issues of subsurface and environmental protection during well construction are highlighted. The estimate of the well construction are calculated.

INCREASE IN PRODUCTIVITY, WELL, BIT, DRILL, RIG.

CONTENT

INTRODUCTION

Among the most important types of industrial products, the production volumes of which determine the current state and level of development of the material and technical base of a particular country, one of the main places is given to the production and consumption of petroleum products, as well as the extraction of oil and gas.

The decrease in production volumes is associated with the depletion of deposit reserves, wear and tear of fixed assets. The solution to this problem is possible only by introducing new deposit s into development, as well as by developing deeper horizons.

To do this, it is necessary to increase the volume of drilling and workover of wells, mainly by increasing the technical and economic indicators of drilling by increasing labor productivity and improving the technological base. The growth of labor productivity depends on the drilling technology (repair) and the qualifications of workers, and the improvement of the technological base is possible by introducing new developments and increasing research work in this industry.

The need to develop the country's economy puts the oil and gas industry workers the task of increasing efficiency and improving the quality of drilling. This task includes both quantitative and qualitative growth: improving equipment and technology for drilling wells, increasing the productivity of drilling operations and reducing their cost. Considerable reserves lie in improving the quality of penetration of oil and gas reservoirs during drilling, accelerating sampling and testing, improving well designs and reducing metal consumption, increasing the durability of fastening and separating oil and gas bearing horizons.

Nowadays, more and more stringent environmental and economic requirements are imposed on well construction. Well construction and operation should have minimal impact on the ecosystem. Deposit development should not pursue the goal of its fastest development, but its maximum oil and gas recovery with minimal damage to the environment.

1 GEOLOGICAL AND TECHNICAL CONDITIONS FOR CONDUCTING DRILLING WORKS

1.1 Geographical location of the work area

Sakhalinsky gas condensate deposit

Sakhalinsky oil and gas condensate deposit was discovered by DP Poltavanaftogazgeologiya in 1981 year. Administratively, the deposit is located in the Krasnokutsk district of Kharkiv region of Ukraine. In the area of the deposit, there are villages: Kustorovka, Komsomolskoye, Nastenkovka. The town of Krasnokutsk, which is a regional center, is located 10-15 km from the deposit (Fig. 1.1).

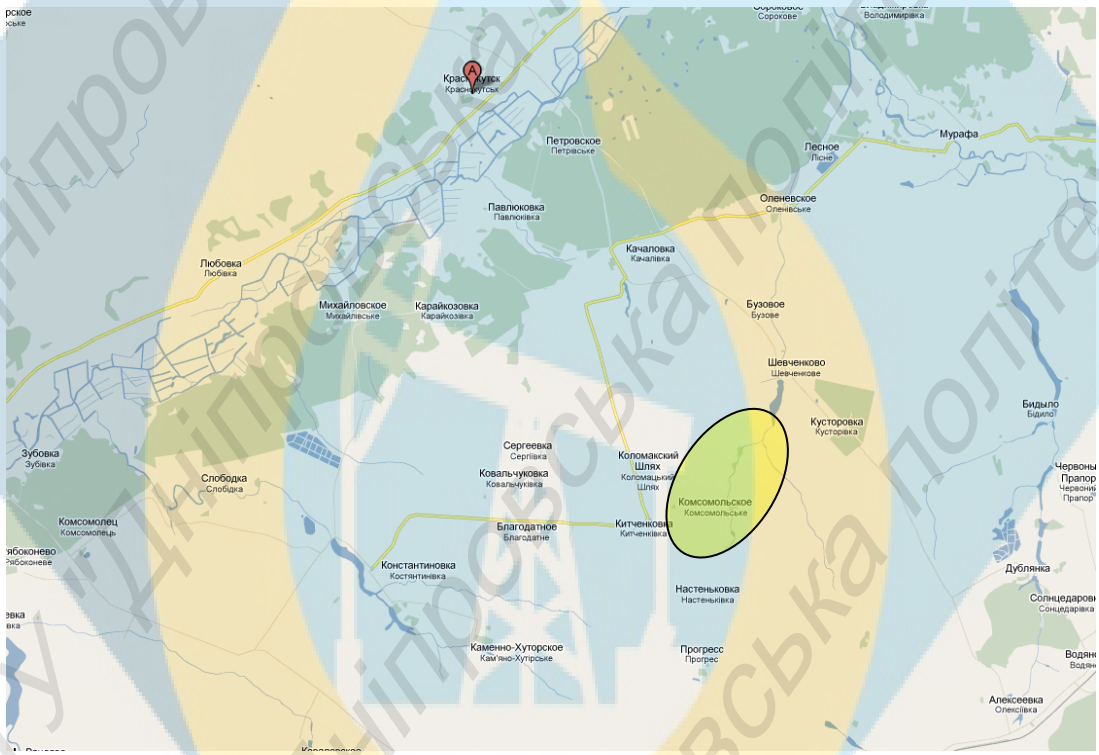


Figure 1.1 - Location of Sakhalinsky deposit

The geological structure of the deposit involves rocks of the Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Paleogene, and Neogene-Quaternary systems.

The deposit is located in the central part of the northern side of the Donets graben. According to seismic profiling data, it is an asymmetric brachyanticlinal fold

with a steep southern wing, the structure of which is complicated by a salt stock. Along the base of the Upper Visean deposits, the fold size is 5x6 km, the amplitude is 450 m.

The fold has a NW strike and is broken by numerous faults of a normal fault. Regional fault with the amplitude from 50 to 125 m, divides Sakhalinsky deposit into eastern and western parts. The fault plane separates the hydrocarbon deposits of the raised and lowered blocks.

Along the top of the productive horizon of the Moscow stage, the arch of Sakhalinsky uplift is contoured in the western block by the isohypsum - 3400 m, in the east - -3250 m. Deposits of Moscovian stage are related to both gas and oil and oil. Gas deposits of the productive horizon of Serpukhovian stage are located at a depth of 4280–4308 m.

The deposits are stratal, vaulted, tectonically (less often lithologically) screened. Reservoirs are sandstones. The porosity of gas-saturated sandstones is 10–12%. The gas is methane. The density of degassed oil is 828–850 kg / m³. The sulfur content in oil is 0.046–0.056 mass. %.

According to the latest data, the gas reserves of Sakhalinsky deposit by category A + B + C1 are 15 billion m^3, condensate and oil - 1.7 million tons each. Contrary to the opinion spread by the media, this is by no means the largest deposit in Ukraine. So, the reserves of Shebelinsky gas deposit (discovered in 1950 in the same Kharkiv region are estimated at 650 billion m^3 of gas. And although the deposit has already been practically worked out, even its residual reserves exceed the original reserves of Sakhalinsky deposit.

1.2 Geological structure of the site

According to the adopted scheme of oil and gas geological zoning, Sakhalinsky deposit is located within Talalayivsko-Rybatsky oil and gas region, between two such large oil and gas accumulation zones as Kotelevsko-Berezivskaya and Bugrevativsko-

Kachalivskaya. At the deposit, oil and gas deposits were found in the deposits of the Upper Carboniferous (reservoir K-6), the Moscovian stage (layers M-1, M-2a, M-26) of the Middle Carboniferous and Serpukhovian (layers C-4, C-5) and Visean (layers B-14, B-16, B-22) of the Lower Carboniferous stages.

Oil deposits in the K-6, M-1, M-2a, M-26, V-14 are formations and tectonically shielded vaults. Gas deposits C-4, V-14, V-16 are layers, vaults, lithologically and tectonically shielded. Gas deposits of horizons C-5, V-22 are massively stratal and stratal, tectonically screened.

The initial maximum flow rate from the C-5 formation was 748.1 thousand m^3 / day at the 25.97 mm orifice with a drawdown of 13.03 MPa, the minimum gas flow rate from the C-4 formation was 10 thousand m^3 / day at the 0.25 orifice mm (well No. 8). In well No. 9, which was drilled in the block where the design well No. 115 is being laid, a gas inflow was obtained from the C-5 horizon with an estimated flow rate of 180 thousand m^3 / day. In St. №15, the estimated flow rate was 96 thousand m^3 / day.

Reservoirs of the C-5 formation are mesomictic sandstones and quartz with carbonate-clayey, in places quartz cement, with porosity, according to laboratory core studies - 10-15.8%, gas permeability - 1.0-233.03-10 " 15 m^2.

Caps for productive strata are packs of dense practically impermeable silty-argilite rocks, 30-170 m thick.

The deposit is characterized by typical methane gases with methane content in the C-4 - C-5 (-s, - b) formations - 84%, methane homologues (ethane-propane, butane fraction) 9-12%.

According to the type of formation waters, the amount of mineralization, the degree of metamorphization and the closeness of the hydrogeology of the subsoil, two hydrodynamic zones are distinguished within Sakhalinsky deposit: active (Cenozoic and Cretaceous aquiferous complexes) and delayed (Triassic, Permian, Carboniferous aquifers) water exchange.

The formation waters of the Middle Carboniferous complex (Bashkirian, Moscovian subcomplexes) in terms of chemical composition are of the calcium chlo-

ride type with a mineralization of 169.5-248.9 g / l. The waters of the Lower Carboniferous and Middle Carboniferous complexes of Sakhalinsky deposit are characterized by a high content (up to 1764 cm^3 / l) of dissolved gases of hydrocarbon composition.

The formation waters of the overlying Upper Carboniferous and Permian-Triassic complexes are of the calcium chloride type with a salinity of 30-160 g / l and a metamorphization coefficient of 0.84-0.86.

The Cretaceous aquifer of the upper hydrodynamic zone is confined to the sands and sandstones of the Cenomanian stage, fractured chalk-marl formations of the Upper Cretaceous and sandstones of the Lower Cretaceous. Produced water flow rates reach 240-2500 m^3 / day at dynamic levels of 30-90m. Mineralization of groundwater is 0.30-3.1 g / l, type - sodium bicarbonate.

The formation waters of the Cenozoic aquifer are confined to Quaternary aluvial sediments, sands and sandstones of the Novopetrovsk, Mezhgorsk, Buchak formations; in terms of chemical composition, they belong to the hydrocarbonate-sodium type with a salinity of 0.7-0.9 g / l. The most water-enriched is the Buchak-Kanev aquifer with flow rates of 140-250 m^3 / day with dynamic drops of 20-25 m. This aquifer is one of the main sources of water supply.

For the complete stratigraphic and lithological-facies characteristics of the open section, its correlation, determination of the reservoir-filtration properties of reservoir intervals and test intervals in the design well, a complex of industrial-geophysical studies is planned.

Perforation of the production casing in the intervals of occurrence of the productive horizon C-5 is planned to be carried out by perforators of the “Spiral Shogan” type.

1.3 Lithological and stratigraphic characteristics of the well section

Table 1.1 - Stratigraphic section of the well, occurrence elements.

Depth of occurrence, m		Stratigraphic division		Elements of bedding (falling) of layers along the bottom, hail.	Vug coefficient in the interval
from (top)	to (bottom)	name	index		
1	2	3	2	5	6
0	325	Cenozoic group Mesozoic group	K_Z M_Z		0-325 m K = 1.05
		Cretaceous system:	K		
325	1050	- upper section	K_2	1-2	
1050	1215	lower section	K_1	1-2	325-2450 m
		Jurassic system:	J		
1215	1585	- upper section	J_3	2-3	K = 1.18
1585	1755	- middle department	J_2	2-3	
		Triassic system:			
1755	2030	- argillaceous stratum	Tg	2-3	
2030	2085	- sandy carbonate strata	T_{PK}	2-3	
2085	2200	- sand mass	T_P	2-3	
2200	2450	- sandy-argillaceous strata	T_{PG}	2-3	
		Paleozoic group Permian system:	P_Z R		
2450	2670	- lower section of the Carboniferous system:	P_{1C}	3-4	2450-4500 m K = 1.20
2670	3300	- upper section	C_3	3-4	
		- middle department	C_2		
3300	3700	Moscow tier	C_{2m}	4-5	
3700	4225	Bashkirian stage	C_{2b}	-II-	
		- lower section	C_1		
4225	4500	Upper Serpukhovian substage	C_{1s2}	-II-	

Table 1.2 - Lithological characteristics of the well section

Stratigraphic subdivision index	Interval, m		Rock		Standard description of the rock: full name, characteristic features (structure, texture, mineral composition, etc.)
	from (top)	before (bottom)	short name	% in the interval	
1	2	3	4	5	6
Q + N	0	80	sands loams clays	50 10 40	Quartz sands with interlayers of variegated clays, yellow-brown loams
R	80	325	sands clays marls sandstones	50 30 10 10	Sandy-clayey formations, mixed-grained sands, light gray, blue, sandy marls with interlayers of sandstones
K2	325	1050	a piece of chalk marls sands clays	 80 10 5 5	Chalk with interlayers of marls, in the lower part - quartz-glauconite sands, with interlayers of greenish-gray clays
K1	1050	1215	sands sandstones clays	65 20 50	Light gray sands of various grains with interlayers of sandstones and calcareous blue-gray clays
J3	1215	1585	clays sandstones siltstone limestones	55 25 50 5	Intercalation of clays with sandstones, siltstones and limestones

1	2	3	4	5	6
J2	1585	1755	clays siltstone sandstones	70 10 20	Clays with interlayers of sandstones in the upper part, and silt-stones
T	1755	2450	sandstones clays limestones	65 30 5	A thick continental stratum of sandy-clayey formations, which, according to facies-lithological characteristics, is divided into clayey, sandy-carbonate, sandy and sandy-clayey strata. Sand-stones grayish-green, silty, grayish clays, greenery, brown
P1	2450	2670	dolomites limestones clays sandstones anhydrite siltstone	20 20 35 5 10 10	Interlayering of dolomites, anhydrite with limestones, clays and siltstone
C3	2670	3300	sandstones mudstone siltstone limestones	45 45 5 5	Alternation of thick sandy strata and clayey packs with thin lay-ers of siltstone and limestone
C2m	3300	3700	sandstones mudstone siltstone limestones	40 40 10 10	Intercalation of sandstones and dense silty mudstones with thin limestone interlayers
C2b	3700	4225	sandstones mudstone	30 30	Alternation of sandstones with siltstones and limestones, in the lower part of the watch of powerful limestones from mudstones

1	2	3	4	5	6
			limestone siltstone	20 20	
C1s2	4225	4500	mudstone sandstones siltstone	45 25 30	Intercalation of mudstone with sandstones and siltstone

Table 1.3 - Physical and mechanical properties of rocks along the well section

Strati-graphic unit	Interval, m		Short name of the rock	Densi-ty, g / cm^3	Porosi-ty,%	Permea-bility, mD	Clayi ness, %	Car-bona te, %	Sa-linity , %	Con-tinuit y of the breed	Stamp hard-ness MPa	Layer-ing breeds	Abrasive-ness ac-cording to Baron, mg	Industrial breed cat-egory (soft, me-dium, etc.)
	from (top)	before (bot-tom)												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Q + N	0	80	sands loams clays	1.65 1.55 1.80	40 30 35	900 10 1	6 70 85	6 5 5	0 0 0	1.0 1.5 3.5		2.0 1.5 1.0		soft - // - - // -
P_{2-1}	80	325	sands marls sandstones	1.65 2.30 2.55	40 10 25	900 5 650	6 60 6-12	6 40 6	0 0 0	1.0 1.5 1.0	 400 320	2.0 1.0 1.0	 0.7 14.0	 - // -
K_2	325	1050	a piece of chalk marls sands clays	2.30 2.30 1.65 1.80	45 10-15 35 35	1 1-10 900-850 1-9	5 50-55 12 15-90	95 45 3-8 4	0 0 0 0	1.5 1.5 1.0 3.0	80 420 240 90	1.0 1.0 2.0 2.0 '	1,2 0.7 0.3	soft
K_1	1050	1215	sands sandstones clays	1.65 2.55 1.80	40 25 26-28	850 650 9	12 6-12 12-85	3-8 6 4	0 0 0	1.0 1.0 3.0	240 460 120	2.0 1.0 2.0	 14.0 0,4	
J_3	1215	1585	clays sandstones	1.65-2 2.60	17-30 25	1-9 550	180-90 20-30	6-8 4-9	0 0	3.0 1.0	120 320	3.0 1.0	0,4 21.5	soft - // -

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			limestones	2.60	4	10	12	85	0	1.5	1310	1.5	1,3	average
J_2	1585	1755	clays	1.65-2	17-30	1-9	80-90	6-8	0	3.0	120	3.0	0,4	soft
			sandstones	2.60	25	550	20-30	4-9	0	1.0	320	1.0.	21.5	- // -
			sandstones	2.60	23	500	19-25	6	0	1.0	460	1.0	26.2	- // -
T	1755	2450	clays	2.00	14-20	5-9	75-85	6-9	0	3.5	180	3.0	6.2	- // -
			limestones	2.60	4	10	12	85	0	1.5	1240	1.5	1.4	average
			dolomites	2.70	2	1	0	60	10-15	1.5	2300	1.0	5.8	solid
			limestones	2.60	4	10	12	85	0	1.5	1500	1.5	1.4	-II -
P_1	2450	2670	clays	2.25	30	9	75	9	0	3.5	320	1.0	1.1	soft
			sandstones	2.60	25	500	12	28	0	1.5	320	3.0	21.5	- // -
			anhydrite	2.75	2	1	0	60	10-15	1.5	2300	1.0	5.8	solid
			siltstone	2.4	10	5	50	6	0	1.5	580	1.0	10.3	average
			sandstones	2.60	23	500	30	8	0	1.0	1000	1.0	36.2	average
C_3	2670	3300	mudstone	2.30	10	9	70	9	0	3.0	380	3.0	1.4	soft
			siltstone	2.40	10	5	55	5	0	1.5	580	1.0	10.3	average
			limestones	2.60	4	10	12	80	0	1.5	1500	1.0	1.4	solid
			sandstones	2.63	12	300	11	8	0	1.0	1000	1.0	55.2	average
C_2m	3300	3700	mudstone	2.35	8-9	1-9	80 32-	6	0	1.0	380	2.0	1.4 22.5	soft
			siltstone	2.35	8-9	1-9	75	8-1	0	1.5	520	1.0		average
			limestones	2.60	4	10	12	80	0	1.5	1500	1.0	1.4	solid
			sandstones	2.64	15-25	1	25-30	3-5	0	1.0	1440	2.0	26.2	average
C_2b	3700	4225	mudstone	2.35	6-8	9	80	9	0	2.5	500	3.0	0.6	soft
			limestones	2.68	2-4	8	10	85-	0	2.0	2500	1.0	0.7	solid

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			siltstone	2.42	9	5	50	90 6	0	1.5	640	1.0	26.0	average
C_1S_2	4225	4500	mudstone sandstones siltstone limestones	2.40 2.64 2.45 2.68	5 9-14 19 3	1 250-900 7 8-9	75 25-30 55 10-12	9 4-5 7 85	0 0 0 0	2.5 2.0 2.0 1.5	560 1370 830 1140	3.0 2.0 1.0 1.0	0.7 45.0 14.0 2.4	- // - - // - - // - - // -

1.4 Oil and gas potential along the well section

Table 1.4 - Oil content

Stratigraphic subdivision index	Interval, m		Collector type	Density, g / cm^2		Mobility on Joint venture μm^2	Sulfur content,% by weight	Paraffin content,% by weight	Free flow rate, m^3 / day	Dissolved gas parameters					
	from (top)	before (bottom)		in reservoir conditions	after degassing					Gas factor, m^3 / t	Hydrogen sulfide content, %	Carbon dioxide content, %	Gas viscosity relative to air	Compressibility factor, 10^{-3} MPa^{-1}	Saturation pressure in reservoir conditions, MPa
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C_2m (M-2a)	3395	3410	pores	0.6699	0.8225	0.03	0.015	0.18	125-197	158-207		0.45	0.812	2.271	24.5

Table 1.5 - Gas content

Stratigraphic subdivision index (stratum, horizon)	Interval, m		Collector type	Condition (gas, condensate)	Content, % by volume		Gas viscosity relative to air	Gas compression ratio in reservoir conditions	Gas flow rate, tis.m^3/day	Density of gas condensate, g/cm^3		Phase permeability, mD
	from (top)	to (bottom)			hydrogen sulfide	carbon				in reservoir conditions	at the wellhead	
1	2	3	4	5	6	7	8	9	10	11	12	13
C, s_2 (C-4)	4250	4285	Pores	gas, cond.		2.03	0.648		43.3-180.8		0.7909	
C, s_2 (C-5)	4310	4340	- // -	- // -		1.05	- // -		120.5-179.5		0.7951	

Table 1.6 - Water content

Stratigraphic subdivision index	Interval, m		Collector type	Viscosity, g / cm^3	Free flow rate, m^3 / day	Phase permeability, mD	Chemical composition of water in% mg-equivalent form						Mineralization degree, g / l	Sulin type of water (SFN-sulphate-sodium, GKN-sodium hydrocarbonate, CLM-chloromagnesium; CCL-calcium chloride)	Treat a drinking water supply (YES, NO)
							anions			cations					
	from (top)	before (bottom)					CO_2	SO_4	HCO_3	Na^{++}	Mg^{++}	Ca^{++}			
KZ	0	325	pores.	1.000-1.010	140.0-150.0								0.7-0.9	gkn	YES
K	325	1215	- // -	1.000-1.010	240.0-2500.0								0.3-3.1	- // -	YES
T	1755	2450		1.050-1.060	100.0-150.0								30.0-161.0	hcl	YES
C3-C2	2670	4225		1.164	0.3-23.7								169.5-248.9	- // -	YES
clS2	4225	4500		1.164	4.7		49.80	0.09	0.11	36.22	5.01	8.77	156.04-222.2	- // -	YES

Table 1.7 - Data on pressure and temperature along the well section

(in columns 6, 9, 12, 15, 17, the symbols of the source of obtaining gradients are put down: PSR - forecast for exploration for seismic data, PFG - forecast for geophysical studies, RFZ - calculation based on actual measurements in wells)

Strati-graphic subdivi-sion in-dex	Interval, m		Pressure gradient												Temperature at the end of the interval	
	from (top)	to (bot-tom)	reservoir			pore			hydraulic fracturing			mountain				
			MPa / m		a source	MPa / m		a sourc e	MPa / m		a sourc e	MPa / m		source of receipt		
			from (top)	before (bot-tom)		from (dried out)	be-fore (bot-tom)		from (top)	before (bot-tom)		from (top)	to (bot-tom)		° C	a sourc e
one	2	3			b	7	eight	nine	10	eleven	12	13	four-teen	fifteen	six-teen	17
KZ	0	325	0.0100	0.0100	RFZ				0.0156	0.0156	RFZ	0.0204	0.0204	Forecast		RFZ
TO	325	1215	0.0100	0.0103	*-II -*				0.0156	0.0158	*-II -*	0.0204	0.0205	-II -	36	*-II -*
J	1215	1755	0.0103	0.0103	*-II -*				0.0158	0.0159	*-II -*	0.0205	0.0208	-II -	49	*-II -*
T	1755	2450	0.0103	0.0103	*-II -*				0.0159	0.0163	*-II -*	0.0208	0.0215	-II -	62	*-II -*
R	2450	2670	0.0103	0.0104	*-II -*				0.0163	0.0165	*-II -*	0.0215	0.0217	-II -	67	*-II -*
C3	2670	3300	0.0104	0.0104	*-II -*				0.0165	0.0167	*-II -*	0.0217	0.0221	-II -	80	*-II -*
C2t	3300	3700	0.0104	0.0105	*-II -*				0.0167	0.0169	*-II -*	0.0221	0.0224	-II -	90	*-II -*
c2b	3700	4235	0.0105	0.0105	*-II -*				0.0169	0.0171	*-II -*	0.0224	0.0227	-II -	102	*-II -*
C, s2	4235	4500	0.0105	0.0106	*-II -*				0.0171	0.0172	*-II -*	0.0227	0.0228	-II -	109	*-II -*

Relative density of gas in air - b = 0.648

Conclusions for the section

In the section, the following is given: geographical location, overview of the previously conducted geological and geophysical studies and geological characteristics of the area of work. The following is described: stratigraphy, tectonics and physicochemical properties of formation fluids within a given area.

2 WELL DESIGN.
SELECTION OF DRILLING EQUIPMENT AND TOOLS

2.1 Selection and substantiation of the drilling method

The selection of the most effective drilling method is due to the tasks that must be solved in the development or improvement of drilling technology in specific geological and technical conditions.

When drilling oil and gas wells, drilling methods have become widespread: rotary, hydraulic downhole motors and drilling with electric drills. The drilling of the project well will be carried out in a rotary way.

2.2. Well design

The well design is designed based on the expected geological section of the well, taking into account possible complications during the drilling process. Data on the values of pressures and possible complications are given in the geological part of the project and are shown on the combined pressure graph.

Based on reservoir pressures and hydraulic fracturing pressures, taking into account various complications, taking into account the permissible values of the exit from under the shoe of the previous casing, as well as the experience of drilling in this area, the following well design is designed:

A conductor 324 mm in diameter is lowered to a depth of 350 m into the top of the Cretaceous deposits in order to cover the unstable, absorbing rocks of the Cenozoic, as well as to prevent contamination of aquifers used for drinking with drilling fluid chemicals.

Cemented to the surface.

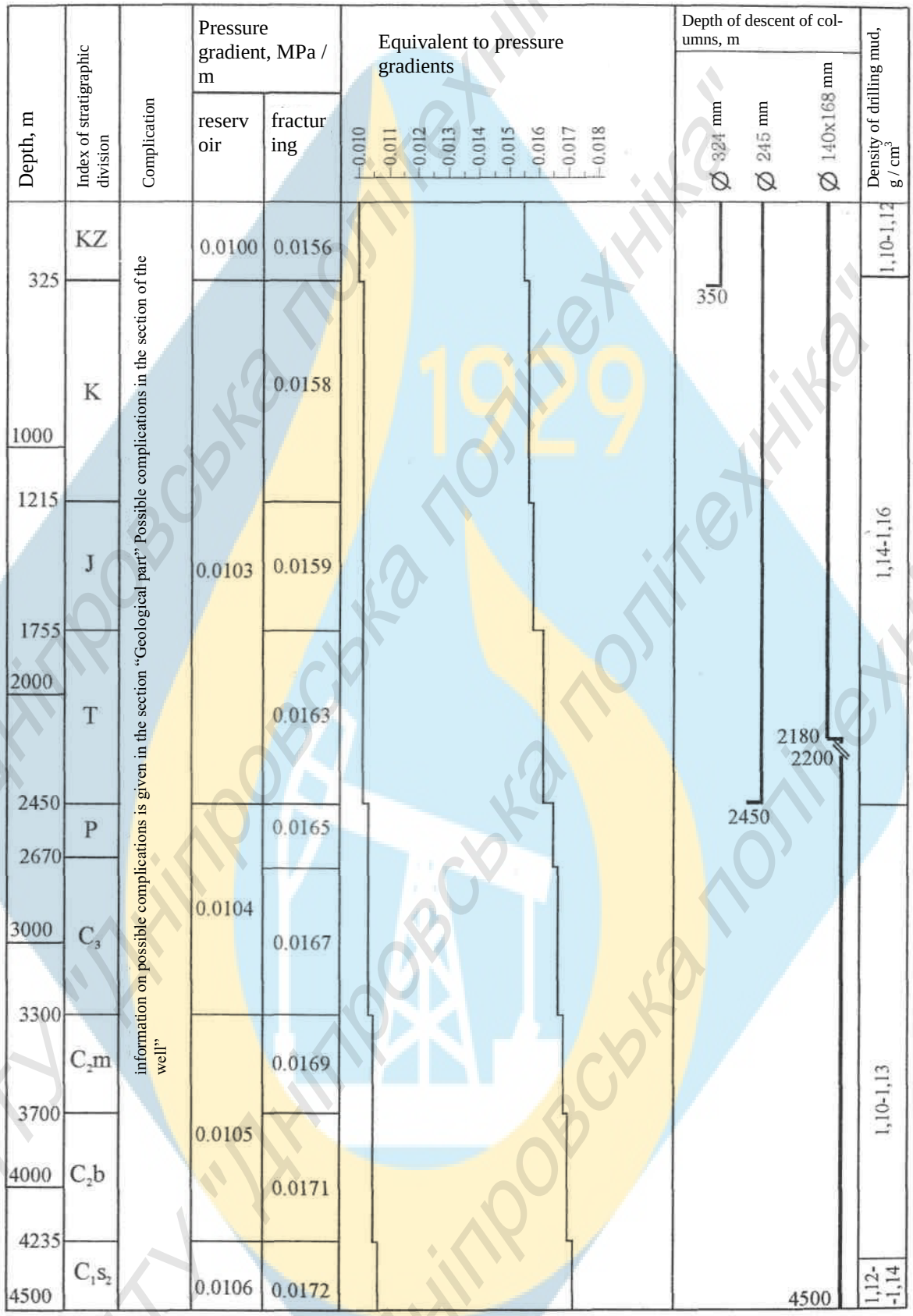


Figure 2.1 - Combined pressure graph

An intermediate string - 245 mm is lowered to a depth of 2450 m in order to overlap the chalk deposits, prone to swelling, strata of terrigenous rocks of the Jurassic and Triassic, where possible enrichment of the drilling fluid with a clay phase and its absorption, into the top of the Lower Permian. The string is also required to reliably equip the wellhead with anti-kickout equipment before opening the expected productive horizons during further drilling.

The column is cemented along its entire length, up to the surface.

The production string - 146/168 mm - is lowered in the interval 0-4500 m.

The column is cemented along its entire length.

1. In accordance with the initial data, the diameter of the production casing

$$d_{ek} = 146 \text{ mm}.$$

2. Diameter of a drill bit for production casing

$$D_d^{ek} = d_m^{ek} + 2\delta, \quad (1)$$

Where d_m^{ek}- diameter of the production casing collar; for a given production casing d_m^{ek}= 166 mm;

δ - size of the gap between the production casing collar and the wellbore wall, since the production casing diameter is equal to d_{ek} = 146 mm, then we take δ = 10 mm.

$$D_d^{ek} = 146 + 210 = 166 \text{ mm}.$$

In accordance with GOST, we take D_d^{ek}215.5 mm for drill bits.

3. Determine the inner diameter of the intermediate casing

$$d_{vn}^{pr} = D_d^{ek} + (6 \div 8), \quad (2)$$

$$d_{vn}^{pr} = 190.5 + 6 = 196.5 \text{ mm}.$$

We accept in accordance with GOST for casing pipes

$$d_n^{pr} = 219 \text{ mm}; \; d_{vn}^{pr} = 210.1 \text{ mm}; \; d_m^{pr} = 245 \text{ mm}.$$

4. Determine the diameter of the bit for drilling under the intermediate string

$$D_d^{pr} = 245 + 2\,20 = 285 \text{ mm}.$$

We accept in accordance with GOST for drilling bits $D_d^{pr} = 295.3$ mm.

5. Determine the inner diameter of the conductor

$$d_{vn}^{k} = 295.3 + 6 = 301.3 \text{ mm.}$$

We accept in accordance with GOST for casing pipes

$$d_{n}^{k} = 324 \text{ mm}; \; d_{vn}^{k} = 301.9 \text{ mm}; \; d_{m}^{k} = 351 \text{ mm.}$$

6. Determine the diameter of the drill bit for surface drilling

$$D_{d}^{pr} = 324 + 2\ 30 = 384 \text{ mm.}$$

We accept $D_{d}^{pr} = 393.7$ mm drill bits in accordance with GOST.

Cementing of casing strings is carried out for the entire length of the string.

The calculation results are summarized in the table.

Table 2.2 - Summary table of casing strings

Column name	Column lowering depth, m	Column diameter, mm	Bit diameter, mm	Cementing interval, m
Conductor	350	324	393.7	0-350
Intermediate column	2450	219	295.3	0-2450
Production casing	4500	146	215.9	0-4500

2.3 Drilling technique

2.3.1 Selection of rock cutting tools

Taking into account the physical and mechanical properties of rocks and the design of the well, we take the following rock-breaking tool.

For drilling in the interval of 0-350 m - blade bit 393.7 SGVU.

For drilling in the range of 350-2450 m - roller cone bits 295.3 SGV, 295.3 SGNU, 295.3 MSGAU, TZGNU.

For drilling in the interval of 2450-4500 m - roller cone bits 215.9 SGV, 215.9 SGVU and 215.9 MZGAU.

2.3.2 Drill string

1. The diameter of the drill collar is selected taking into account the diameter of the bit based on the following conditions

$$\frac{d_{UBT}}{D_d} = 0.75 \div 0.85 \text{ at } D_d \leq 295.3 \text{ mm;} \quad (3)$$

Then

$$d_{UBT} = (0.75 \div 0.85) \cdot D_d = (0.75 \div 0.85) \cdot 215.5 = 162 \div 192 \text{ mm.}$$

In accordance with GOST, we take d_{UBT} =165 mm for drill collars.

The weight of 1 m of these pipes is q_{UBT} = 1470 N.

The diameter of the drill pipes is selected from the ratio

$$\frac{d_{bt}}{d_{UBT}} = 0.75 \div 0.80, \quad (4)$$

Then

$$d_{bt} = (0.75 \div 0.80) \cdot d_{UBT} = (0.75 \div 0.80) \cdot 146 = 110 \div 117 \text{ mm.}$$

In accordance with GOST, we take 114 mm for drill pipes.d_{bt} =

Based on the proposed flow rate and dimensions of the pumping facilities, as well as taking into account the established practice of drilling operations in this area, we take the final drilling diameter of 215.9 mm, and the production string diameter of 168 mm.

The casing diameters and directions are selected in accordance with the size of the annular gap between the bit and the running casing string and the annular gap between the casing string and the bit running into it for the next interval. The diameters of the drill and casing bits are 295.3 mm, 393.7 mm, and the diameters of the casing strings: 245 mm, 324 mm, respectively.

The lifting height of the grouting slurry in the annulus is determined on the basis of the current instructional and methodological materials. The lifting height of the cement slurry behind all the columns should be made up to the wellhead [9].

2.3.3 Well flushing

Substantiation of the density of the flushing fluid

The density of the drilling fluid is selected according to the combined pressure graph and refined for each interval of compatible drilling conditions using the formula

$$\rho_{pr} = \frac{\alpha P_{pl}}{gH}; \quad (5)$$

Where R_{pl} - reservoir pressure in the well interval for which the ρ_{etc};

g - acceleration due to gravity, m / s^2;

H - depth of the top of the well interval, m;

α - standard coefficient, which, in accordance with the requirements of the rules for conducting drilling operations, determines the pressure reserve in the borehole above the reservoir.

Density in the range of 0-350 m (since H <1200, we take α = 1.12).

$$\rho_{np} = \frac{1.12 \cdot 300 \cdot 10000}{9.81 \cdot 350} = 1123 \text{ kg / m}^3.$$

We accept ρ_{np} =1120 kg / m^3.

Density in the range 350-2450 m (since H> 1500 then we take α= 1.05).

$$\rho_{np} = \frac{1.05 \cdot 1300 \cdot 11600}{9.81 \cdot 2450} = 1141 \text{ kg / m}^3.$$

We accept ρ_{pr} =1140 kg / m^3.

Density in the range of 2450-4500 m (since H> 1500 then we take α= 1.05).

$$\rho_{pr} = \frac{1.05 \cdot 3050 \cdot 10000}{9.81 \cdot 4500} = 1130 \text{ kg / m}^3.$$

We accept ρ_{np} =1130 kg / m^3.

Drilling fluids perform functions that determine not only the success and speed of drilling, but also the commissioning of a well with maximum productivity. The main of these functions are:

– removal of cuttings from under the bit, transporting it along the annulus and ensuring its separation on the surface;

– keeping the sludge in suspension when the circulation of the solution is stopped;

– cooling the bit and facilitating the destruction of the rock in the bottomhole zone;

– creating pressure from the borehole wall to prevent water, oil and gas manifestations;

– providing physicochemical effects on the walls of the well, preventing their collapse;

– ensuring the preservation of the permeability of the productive formation during its opening;

– power transmission to the downhole hydraulic motor (when used), etc.

When drilling the projected well, the following drilling fluids will be used.

In the process of drilling, a clay mud with a density of 1.12 g / cm^3, treated with soda ash, PVLR, will be used under the conductor to prevent talus, landslides, losses.

Clay mud parameters:

ρ = 1.12 g / cm^3,

T = 25 - 45 sec.,

B = 6 - 8 cm^3 / 30min.,

K = 1.5 mm,

SNC = 10-30 mg / cm^3;

pH = 8.

When drilling in the interval of 350-2450 m, narrowing of the wellbore, swelling of chalk, sticking is possible. Therefore, it provides for a humate-acrylic solution treated with soda ash, hypanol, labricol, oil:

Solution parameters:

ρ = 1.14 g / cm^3,

T = 40-70 sec,

B = 4-6 cm^3 / 30min.,

K = 1 mm,

CHC = 20-30 mgf / cm^2,

pH = 9

When drilling within the interval of 2450-4500 m, coagulation of the solution, caverns, troughs, and sticks is possible. Here, a polymer-potassium solution is used with additives KSI, lacrice, soda ash, oil, PAA, cellulose reagent, labricol. Solution characteristics:

ρ = 1.13 g / cm^3,

T = 40-60 sec,

B = 6-8 cm^3 / 30min,

SNS = 20/40 mgf / cm^2,

K = 1 mm,

pH = 8-9.

2.4 Drilling technology

2.4.1 Calculating the axial load on a bit

The value of the axial load on the bit Pdol, which should ensure the volumetric destruction of the bottomhole, taking into account the indicators of the mechanical properties of rocks and structural data on the contact area of the teeth of the bit with the bottomhole, is determined by the formula:

$$R_{dol.} = \alpha P_{sh} F_k, \quad (6)$$

where α is an empirical coefficient that takes into account changes in bottomhole conditions for changes in hardness (α = 0.3 - 1.59);

Psh - rock hardness according to L.A. Schreiner"s method (by stamp); kg / mm^2.

F_k is the contact area of the bit teeth with the bottomhole mm2, determined by the formula of V.S. Fedorov:

$F_k = (D_{dol.} H \delta) / 2$, mm. (7)

where η is the coefficient of overlapping teeth;

δ - coefficient of teeth blunting.

Thus, $R_{dol.} = \alpha \cdot P_{sh} \cdot D_{dol.} \cdot H \cdot \delta / 2$.

For a 393.7 mm bit:

$R_{dol.}$ = 1 250 393.7 1.21 1/2 = 59547.5 H = 6 t.

For bits with a diameter of 295.3 mm:

$R_{dol.}$ = 1.2 300 295.3 1.14 2/2 = 151190.4 H = 15 t.

For a bit with a diameter of 215.9 mm:

$R_{dol.}$ = 1.59 350 215.9 1.4 2/2 = 168 207.69 H = 17 t.

2.4.2 Calculation of the rotational speed of the bit

It is determined by the following formula:

$N = 60 v / \pi D_{dol.}$, (Rpm), (8)

where v is the average circumferential speed of rotation of the bit (V = 0.8 - 2.0).

For a 393.7 mm bit:

N = 60 0.8 / 3.14 0.3937 = 45.07 rpm, i.e. drilling will be carried out at 1 rotor speed.

For bits with a diameter of 295.3 mm:

N = 60 1.5 / 3.14 0.2953 = 97 rpm, i.e. drilling will be carried out at 3 rotor speeds.

For a bit with a diameter of 215.9 mm:

N = 60 1.0 / 3.14 0.2159 = 88 rpm, i.e. drilling will be carried out at 2 rotor speeds.

2.4.3 Calculation of the amount of flushing liquid

The technologically necessary amount of flushing fluid to ensure timely and uninterrupted removal of cuttings from the bottomhole along the annulus and cleaning the wellbore is found from the ratio:

$$Q = 0.785 (D^2_{dol.} - d^2_{out.b.tr.}) V_{out.}, \quad (9)$$

where V_{out} is the minimum permissible upward flow rate from the condition of high-quality cleaning and the wellbore (the smaller the diameter, the higher it is).

For a 393.7 mm bit:

$Q = 0.785 \cdot (3.9372 - 1.12.) \cdot 3 = 45.9$ l / s.

The pump will operate on 190 mm bushings with a capacity of 46.0 l / s.

For bits with a diameter of 295.3 mm:

$Q = 0.785 \cdot (2.9532 - 1.12.) \cdot 7 = 45.9$ l / s.

The pump will operate on 180 mm bushings with a capacity of 43.0 l / s.

For a bit with a diameter of 215.9 mm:

$Q = 0.785 \cdot (2.1592 - 1.12.) \cdot 8 = 21.7$ l / s.

The pump will operate on 150 mm bushings with a capacity of 22.0 l / s.

2.5. Drilling equipment

2.5.1 Rig selection

We select the drilling rig according to the rated lifting capacity in accordance with the greatest weight of the drill or casing string in the air.

Drilling rig drive type is selected depending on regional conditions. Taking into account the experience of work in this area, the drilling of the projected well will be carried out using a drive from an internal combustion engine.

To determine the maximum weight of the string, we will compile a comparative table of the weight of the drill and casing strings.

Table 2.3 - Weight of drill and casing strings

Indicators	Drill string	Intermediate column	Production casing
Column length	4500	2450	4500
Weight 1 m, N	-	179	91
Column weight, N	142850	438550	409500

Thus, the intermediate column has the maximum weight.

To drill a well, we choose the Uralmash 3D-76 drilling rig.

It is designed for drilling production and exploration wells for oil and gas with a nominal depth of 5000 m in a temperate climate, climatic version "U", category I.

Specifications:

A type	Uralmash 3D-76
Drilling method	Rotary and turbine
Conditional drilling depth with a weight of 1 m. drill string 30 kg., m	5000
Rigging	5x6
Permissible load on the hook during driving and well casing, kN	2250
Wire rope diameter, mm	32
Hook lifting speed when casing strings are walking and elimination of accidents, m / s	0.19
The speed of steady motion when lifting an unloaded elevator, m / s	1.58
Power on the drive (input) shaft of the lifting unit, kW	710
Passage diameter of the rotor table, mm	560
Power on the rotor drive shaft, kW	215
Permissible static load on the rotor table, kN	4000
The moment transmitted by the rotor table, kNm	fifty

Number of main mud pumps, pcs	2
Mud pump drive power, kW	600/530
The highest pressure at the pump outlet (in the manifold), MPa	25
Candle nominal length, m	34
Base height (drill floor elevation), m	6
Rotor table rotation frequency, s (rpm):	
minimal	0.33 (20)
maximum	3.87 (232)
Air pressure in the pneumatic system, MPa (kg / cm)	0.6 (6) - 0.8 (8)
Diesel generator set power (unlimited), kW	3 x 632
Kit weight, t, no more	170
Hook load from the weight of the drill string should not exceed 5 x 6 when rigged	1450 kN

Structure: On the tower-power base there is a drilling tower with elements of a traveling system, a rotor with pneumatic wedges, an AKB-3M2 drill key, and a winch with a hydrodynamic brake. The rotor is driven by a 2PR-50.8 double-row sleeve-roller chain from a drilling winch.

The power unit contains: a gearbox with cardan shafts, a power electric motor for the drive of the winch SDBO-6000 - 710 kW and two electric compressors 4VU1-5 / 9, providing the drilling rig with compressed air (operating pressure of the pneumatic system is 8 kg / cm^2).

In the near-tower structure, two mud pumps are installed on the base, each of them has an individual electric drive, which is carried out by a V-belt transmission from an SMBO-6000-600 / 630 kW electric motor.

AKSA ACQ 1130 diesel generator sets - 3 sets, 824 kW each, Cummins diesel engines (USA), 956 kW each, Stamford generators (Great Britain), designed to supply electric power to electric motors: (rotor drive and winches, drives for mud pumps UNB-600, compressors and other electrical equipment, as well as lighting.

Method of installation and transportation: modular, block, universal transport.

Circulation system TsS 3D-76M

Technical specifications:

1. Useful volume of drilling mud, m^3 160

2. Installed capacity of electrical equipment, kW 60

3. Climatic modification - U, product category 1 (at ambient temperatures from minus 45^o to plus 45^o) in accordance with GOST 15150

Product composition: intermediate block - 2 pcs., receiving block - 1 pc., end block - 1 pc., BHR block with base, switchgear block with cabinet control, cable products and electrical equipment, lamps, control buttons, solution preparation unit and

chemicals BPR-2, a set of platforms for service with railings.

Method of installation and transportation.

The rig design provides for:

– large-block transportation of derrick-winch and hinged blocks on heavy trucks TPP-70 and T-60;

– transportation by medium blocks on trailers and platforms PP40Br with a lifting capacity of 40 tons;

– aggregate method of transportation by general transport [4].

2.5.2 Selecting a pumping unit

A mud pump for flushing a well in specific geological conditions is selected according to the technologically required amount of flushing fluid and the pressure developed at the same time to overcome pressure losses in the elements of the drilling system.

The amount of required flushing fluid when drilling under the production casing is 31.11 l/s. Let us now determine the pressure loss in the circulation system, knowing which it is possible to choose the most rational arrangement of the drilling tool, reasonably select mud pumps and make fuller use of their potential capabilities.

The head loss, kgf / cm^2, in the circulation system of the drilling rig during rotary drilling is determined by the formula:

$$P_{\Sigma} = P_m + P_{b,t.} + P_{k.n.} + P_D, \quad (10)$$

where P_m is the head loshs during the movement of the drilling fluid in the surface pipelines from the pumping section to the drill pipe string, including the standpipe in the drill pipe, the drill hose, as well as the swivel and the leading pipe (head loss in the outer piping of the drilling rig - manifold);

$R_{B.T.}$ - head losses during the movement of drilling fluid in drill pipes and tool joints (pressure losses depend on the depth of the well);

$R_{k.p.}$ - loss of pressure during the movement of drilling fluid in the annular space of the well (pressure loss depends on the depth of the well);

P_D is the head loss when the drilling fluid moves through the drilling holes of the drill bit;

P_m, P_D - do not depend on the depth of the well, and $P_{b.t.}$ and $R_{k.p.}$ increase with the depth of the well.

During the circulation of the cleaning agent, the head losses, kgf / cm^2, are different when pumping water and clay solution and depend on their properties and consumption.

$$P_M = 82{,}6 \cdot \lambda \cdot L_э \cdot \gamma \cdot Q^2/d^5, \quad (11)$$

where λ is the dimensionless coefficient of hydraulic resistance when moving in pipes;

Q - drilling mud flow rate, l / s;

γ is the specific gravity of the solution, g / cm^3;

d - inner diameter of drill pipes, cm;

Le is the equivalent length of onshore pipelines, which is determined by the formula:

$$L_э = L_H \cdot (d/d_H)^5 + L_c \cdot (d/d_c)^5 + L_{sh} \cdot (d/d_{sh})^5 + L_в \cdot (d/d_в)^5 + L_{в.тр} \cdot (d/d_{в.тр})^5 + L_{э.ф.} \cdot (d/d_{э.ф.})^5 \quad (12)$$

where d_H, L_H - inner diameter and length of the injection line from the mud pumps to the riser;

d_c L_c - inner diameter and length of the riser with the drilling rig

ds_h L_{sh} - inner diameter and length of the drill hose;

$d_в$ $L_в$ - inner diameter of the swivel barrel and its length;

$d_{e.f}$ $L_{e.f.}$ - diameter and equivalent length of the filter to be installed under the leading pipe;

$d_{v.tr.}$ $L_{v.tr.}$ - inner diameter and length of the leading pipe.

$$L_e = 30 \cdot (0.107/0.114)^5 = 98.5 + 15 \cdot (0.107/0.114)^5 + 15 \cdot (0.107/0.09)^5 + 2.5 \cdot (0.107/0.09)^5 + 15 \cdot (0.107/0.1)^5 + 2 \cdot (0.107/0.114)^5$$

$$P_t = 82.6 \cdot 0.026 \cdot 96.85 \cdot 1.2 \cdot (31.11)^2/(10.7)^5 = 1.72\ kGf/cm^2$$

$$P_{b.t} = 82.6 \cdot \lambda \cdot \gamma \cdot Q^2 \cdot (l + l_э/l) \cdot L_b/d^5 \quad (13)$$

where L_b is the length of the drill string, m;

le is the equivalent length of the tool joints, m;

l is the distance between the locks, m.

$$P_{b.t} = 82.6 \cdot 0.026 \cdot 2.03 \cdot (31.11)^2 \cdot (1 + 3.5/11) \cdot 4500/(10.7)^5 = 88.6\ kGf/sm^2$$

$$P_{k.p.} = 82.6 \cdot \lambda_1 \cdot \gamma \cdot Q^2 \cdot L/[(D_s - d_H)^3 \cdot (D_s + d_H)^2]. \quad (14)$$

where λ_1 is the coefficient of hydraulic resistance when the drilling fluid moves in the annular (annular) space; Ds - borehole (bit) diameter, cm; d_H - outer diameter of drill pipes, see.

The pressure loss from the tool joints in the annular space is small, therefore it is usually neglected.

$$P_{k.p.} = 82.6 \cdot 0.027 \cdot 2.03 \cdot 31.11^2 \cdot \frac{4500}{[(21.59 - 12.7)^3 \cdot (21.59 + 12.7)^2]}$$

$$= 11.22\ kGf/cm^2,$$

The head loss in the bit, kGf / sm^2, depends on the configuration of the flushing holes, on the number and area of their cross-section, the consumption of the cleaning agent (drilling mud).

$$P_d = C \cdot \gamma \cdot Q^2, \quad (15)$$

where C is the coefficient characterizing the head loss in the drilling holes of the bit, which can be calculated by the formula:

$$C = 0.51/(\mu^2 \cdot f_0^2), \quad (16)$$

where μ is the flow coefficient, f_0 is the total cross-sectional area of the flushing holes, cm^2.

$$C = 0.51/(0.65^2 \cdot 13.05^2) = 7 \cdot 10^{-3}.$$

$$P_Д = 7 \cdot 10^{-3} \cdot 1.2 \cdot 31.11^2 = 8.13\ kGf/cm^2.$$

Let us calculate the total head loss:

$$P_\Sigma = 1.72 + 88.6 + 11.22 + 8.13 = 109.67\ kGf/cm^2.$$

Thus, the technologically necessary amount (flow rate) of flushing fluid to ensure timely and uninterrupted removal of cuttings from the bottomhole along the annulus and cleaning the wellbore, taking into account pressure losses, will be provided by the UNB-600 pump.

Description of mud pump UNB-600:

Mud pump UNB-600 (U86MA2) is designed to supply flushing fluid to the bottomhole when drilling wells up to 5000 m deep. Flushing fluid is pumped through the drill pipe string to the borehole bottom to cool and remove the rock destroyed by the bit, as well as to transfer the flow energy to the turbodrill and its associated bit. Water or clay solution with the presence of oil, alkali, soda and other components is used as a flushing fluid.

Table 2.4 - Technical characteristics of the UNB-600 mud pump:

Power, kWt	600
Number of double-acting pistons:	2
Frequency of double strokes is the highest in min.	65
Piston stroke length, mm	400
Type of gearing of the crank-slider mechanism	helical
Tooth inclination angle, degrees	9 ° 22'00 "
Valve box design	L-shaped double action
Connecting dimensions of the valve group in the valve box	# 9 API Spec 7K
Liquid pressure at the inlet, not less, MPa (kgf / cm^2)	0.1 (1)
Coolant supply system for piston rods	Under pressure from the auxiliary centrifugal pump with electric drive
Coolant pressure, not less, MPa (kGf / cm^2)	0.15 (1.5)
Oil supply system to the friction units of the mechanical part:	1. Gravity from collection trays
	2. Dipping in an oil bath
Overall dimensions, mm:	
length	5 100
width	3,000
height	4040
Gearbox housing	Cast
Weight, kg	25450

Two-piston drilling pump UNB-600 in design is horizontal, crank, double-acting.

In the calculation of the main characteristics, it is assumed that the feed coefficient is 1, the efficiency is - 0.85.

Mud pump UNB-600 complies with GOST 6031 in basic parameters.

2.5.3 Rig selection and tackle system calculation

The tower is used for tripping operations and holding the drill string while drilling. Its choice is carried out according to the height H, m, and the carrying capacity Q.

Determine the height of the tower (H, m) by the formula:

$$H = k \cdot L_{св.}, \quad (17)$$

where k is the coefficient that prevents the drill string from being pulled into the crown block when it is over-lifted (usually k = 1.2 - 1.5);

L_w. - the length of the plug, depending on the depth of the well, m.

We accept k = 1.5; L_w. = 32 m.

$$H = 1{,}5 \cdot 32 = 48\,m$$

For tripping operations, we accept a VB 53-320M tower, which is suitable for performing the designed work.

The lifting system of the installation is a chain hoist mechanism consisting of a crane block, a traveling (movable) block, a steel rope, which is a flexible connection between the drawworks and the fixing mechanism of the fixed end of the rope.

As the depth of the wells increases, the weight of the drill strings that have to be lowered and raised increases, and the maximum winding speed of the lead string of the wireline on the winch drum remains practically unchanged for drilling rigs of different classes. Therefore, for each installation, a traveling system is used with its own chain hoist ratio from 4 to 14. This is achieved by using various rigs.

We will calculate the rigging and select the wire rope.

Let's calculate the number of working branches using the formula:

$$m = Q_{cr}/P_l \cdot \eta_m, \quad (18)$$

where Q_{cr} is the weight of the drill, N;

P_l - lifting capacity of the machine winch, N;

H_m - efficiency of the tackle system, equal to 0.8 - 0.9.

Since the drill string will have the greatest weight (90.09 t) when drilling under the production string, we will calculate only for this string:

$m = 900925/(1450000 \cdot 0{,}9) = 5.9$ (we accept 6 branches).

The total number of rope branches with a symmetric system is:

$$m_0 = m + 2 = 6 + 2 = 8.$$

Therefore, a 5 x 6 rig will be used.

The length of the wire rope in the equipment $L_{o.c.}$ depends on the number of strings m in it and the useful height of the tower $h_П$.

$L_{o.c.} = (m + 2)\, h_П + l_3$, where $l_3 = 30$ m is the length of the rope wound on the drum.

$L_{o.c.} = (8 + 2)\, 42 + 30 = 450.$

Then the weight of the rope $G_k = L_o.$ with Q_k, where q_k is the weight of 1 m of the rope.

$G_k = 450. \cdot 33.8 = 15210$ N = 15.21 kN.

Let us determine the largest statistical load on the moving strings of the rope of the tackle system:

$$R_{ts} = L\, q + l_{ubt}\, q_{ubt} + G_{ts}, \qquad (19)$$

where L is the length of the drill pipes, m;

q - weight of 1 m of drill pipes, N

l_{ubt} - collar length, m;

q_{ubt} - weight of 1 m of drill collar, N;

G_{ts} - weight of traveling block, rope and hook, N.

Let's calculate G_{ts}:

$$G_{tc} = G_{tb} + G_{\ rope} + G_{\ hook} \qquad (20)$$

$$G_{ts} = 67000 + 15210 + 35000 = 117.210 \text{ N} = 117.21 \text{ kN}.$$

For a column with a diameter of 324 mm:

$l_{ubt} = 28$ m, $q_{ubt} = 1.56$ kN.

P_{ts} = 28 1560 + 117210 = 160890 = 160.89 kN.

Static load on 1 string: P = P_{ts} / m,

where m is the number of strings in the tackle system.

P = 160.89 / 8 = 20.11 kN.

For a column with a diameter of 245 mm:

L = 364 m, q = 319 N, l_{ubt} = 136 m, q_{ubt} = 1.56 kN.

P_{ts} = 364 319 + 136 1560 + 117210 = 445486 H = 445.49 kN.

Static load per string: P = 445.49 / 8 = 55.69 kN.

For a column with a diameter of 146 mm:

L = 3100 m, q = 319 N, l_{ubt} = 190 m, q_{ubt} = 1.56 kN.

P_{ts} = 3100 319 + 190 1560 + 117210 = 1402510 N = 1402.51 kN,

Static load per string: P = 1402.51 / 8 = 175.31 kN.

Taking into account the calculated static loads, we select a steel wire rope of the right cross lay, type LK-RO, with a structure of 6x31 + 1 m with a diameter of 32 mm (according to GOST 16853-88) [2].

2.6 Well cementing

Initial data

When calculating the cementing of wells, determine:

1) the amount of dry cement;

2) the amount of water for mixing the cement slurry;

3) the amount of displacement fluid;

4) possible maximum pressure by the end of cementing;

5) allowable cementing time;

6) the number of cementing units and cement mixing machines.

Let us calculate the single-stage cementing of each of the casing strings.

Table 2.5 - Initial data for cementing

	Conductor	Intermediate	Production casing
Descent depth (N, m)	350	2450	4500
Bit diameter (D, mm)	393.7	295.3	215.9
Outside diameter of casing pipes (d_1, mm)	324	245	168
Inner diameter of casing pipes (d_2, mm)	305.9	230.5	140
Lifting height of cement grout (N_c, m)	250	3250	4450
Clay slurry density (ρ_p, kg / m^3)	1160	1160	1200
Density of cement grout (ρ_c, kg / m^3)	1860	1860	1860
Installation height of the stop ring from the bottom (h, m)	5	20	20

2.6.1 Calculation of the volume of cement grout

The volume of cement slurry to be injected into the well is determined by the formula:

$$V_{ts} = (\pi / 4) \cdot [K_1 \cdot (D^2 - d_1^2) \cdot Нц + d_2^2 \cdot h], m^3 \quad (21)$$

where K_1 is a coefficient that takes into account the increase in the volume of cement slurry consumed for filling caverns, cracks, and an increase in the well diameter against the calculated (nominal) one.

The value of the K_1 coefficient is determined from the quernogram for each specific well. Typically K_1 ranges from 1.1 to 2.5. In our case, we take $K_1 = 1.5$.

Cementing will be done using pure Portland cement.

For a column with a diameter of 324 mm:

$V_c = 0.785 \cdot [1.15 \cdot (0.3937^2 - 0.324^2) \cdot 350 + 0.3059^2 \cdot 5] = 18.6$ m^3

For a column with a diameter of 245 mm:

$V_c = 0.785 \cdot [1.15 \cdot (0.2953^2 - 0.245^2) \cdot 2450 + 0.2305^2 \cdot 20] = 60.90$ m^3

For a column with a diameter of 146 mm:

Interval 0 - 2350 m:

$V_{g.ts.} = 0.785 \cdot [1.15 \cdot (0.2159^2 - 0.168^2) \cdot 2450 + 0.140^2 \cdot 20] = 40.98$ m^3

Interval 2350 - 4500:

$V_c = 0.785 \cdot [1.15 \cdot (0.225^2 - 0.168^2) \cdot 4500 + 0.140^2 \cdot 20] = 90.59$ m^3

The total volume of cement grout for the production casing: 40.98 + 90.59 = 131.57 m^3

2.6.2 Calculation of the amount of dry cement

The amount of dry cement for the preparation of cement slurry is determined from the expression:

$$Q_{ts} = \rho_{ts} \cdot V_{ts} \cdot 1 / (1 + m), \quad (22)$$

where m is the water-cement ratio;

ρ_{ts} - cement slurry density, kg / m^3, it can be calculated by the formula:

$$\rho_{ts} = [(1 + m) \cdot \rho_{s.ts.} \cdot P_w] / [\rho_w + m \cdot \rho_{c.c.}]. \quad (23)$$

where $\rho_{c.c.}$ - density of dry cement, g / cm^3;

ρ_w is the density of water, g / cm^3.

$\rho_{ts} = [(1 + 0.5) \cdot 3.5. \cdot 1] / [1 + 0.5 \cdot 3.15] = 1.85$ g / cm^3.

For a column with a diameter of 324 mm:

$Q_{ts} = 1.85\ 18.6\ 1 / (1 + 0.5) = 22.94$ t,

For a column with a diameter of 245 mm:

$Q_{ts} = 1.85\ 60.90\ 1 / (1 + 0.5) = 75.11$ t,

For a column with a diameter of 146 mm:

Interval 0 - 2450 m:

$Q_c = 1.85\ 40.98\ 1 / (1 + 0.5) = 50.54$ t.

Interval 2450 - 4500 m:

$Q_{ts} = 1.85 \cdot 90.59 \cdot 1 / (1 + 0.5) = 111.73$ t,

The total volume of cement for the column: $Q_{ts} = 50.54 + 111.73 = 162.27$ tons.

The amount of dry cement that must be prepared, taking into account the losses during mixing of the cement slurry, will be calculated by the formula:

$$Q_{ts1} = K_2 Q_{ts}, \quad (24)$$

where K_2 is a coefficient that takes into account ground losses during mixing of the cement slurry. If mixing is performed without cement mixing machines, K_2 = 1.054-5-1.15, when using cement mixing machines, $K_2 = 1.01$. In our case, $K_2 = 1.01$.

For a column with a diameter of 324 mm:

$Q_{ts1} = 1.01\ 22.94 = 23.17$ t,

For a column with a diameter of 245 mm:

$Q_{ts1} = 1.01\ 75.11 = 75.86$ t,

For a column with a diameter of 146 mm:

Interval 0 - 2450 m:

$Q_{ts1} = 1.0150.54 = 51.04$ t,

Interval 2450 - 4500 m:

$Q_{ts1} = 1.01\ 111.73 = 112.85$ t,

The total amount of dry cement, taking into account losses for the column:

$Q_{ts1} = 51.04 + 112.85 = 163.89$ t.

2.6.3 Calculation of the amount of water

The required amount of water for the preparation of a cement mortar of 50% consistency is found from the expression:

$$V_v = 0.5 Q_{ts}, \quad (25)$$

For a column with a diameter of 324 mm:

$V_w = 0.5\ 23.17 = 11.59\ m^3$.

For a column with a diameter of 245 mm:

$V_w = 0.5\ 75.86 = 37.93\ m^3$.

For a column with a diameter of 146 mm:

$V_w = 0.5\ 51.04 + 0.5\ 112.85 = 81.95\ m^3$.

2.6.4 Calculation of the amount of displacement fluid

The required amount of displacement fluid (which is often used as drilling mud) is determined by the formula:

$$V_{pr} = \Delta\ \pi\ d_2^2\ (H - h) / 4, \quad (26)$$

where Δ is the coefficient taking into account the compression of the clay solution ($\Delta = 1.03 - 1.05$).

Substituting the values, we get:

For a column with a diameter of 324 mm:

$V_{pr} = 1.03\ 3.14\ 0.3059^2\ (350 - 5) / 4 = 26.11\ m^3$.

For a column with a diameter of 245 mm:

$V_{pr} = 1.03\ 3.14\ 0.2305^2\ (2450 - 20) / 4 = 104.39\ m^3$.

For a column with a diameter of 146 mm:

$V_{pr} = 1.03\ 3.14\ 0.133^2\ (4500 - 20) / 4 = 64.07\ m^3$.

Very often in practice, the following empirical formula is used to quickly determine V_{pr}:

$$V_{pr} = D_н^2\ H_1 / 2, \quad (27)$$

where $D_н$ is the nominal outer diameter of the string of pipes lowered into the well, in inches;

$D_н^2 / 2$ - the amount of displacement fluid required to fill 1 m of lowered pipes, l;

H_1 - installation depth of the stop ring, i.e. the depth of squeezing the cement slurry.

For the production casing:

$V_{pr} = 5\ 4500/2 = 11250\ l = 11.3\ m^3$.

2.6.5 Calculation of injection pressure

The maximum pressure before seating the top plug on the thrust ring is determined from the equation:

$$P_{max} = P_1 + P_2, \quad (28)$$

where P_1 is the pressure required to overcome the resistance caught by the density differences of the liquid in the pipes and the annulus;

P_2 is the pressure required to overcome hydraulic resistance.

$$P_1 = (1/105) \cdot [(H_c - h) \cdot (\rho_c - \rho_p)], \text{ MPa} \quad (29)$$

The value of P_2 is usually found using empirical formulas. The most common is the Shishchenko-Baklanov formula; for wells with a depth of more than 1500 m (Fig. 2.1, 2.2):

$$P_2 = 0.001 H + 1.6 \text{ MPa}. \quad (\text{thirty})$$

For a column with a diameter of 324 mm:

$P_1 = (1/105) \cdot [(250 - 5) \cdot (1420 - 1100)] = 0.8$ MPa

$P_2 = 0.001\ 250 + 1.6 = 1.85$ MPa.

$P_{max} = 0.8 + 1.85 = 2.65$ MPa.

For a column with a diameter of 245 mm:

$P_1 = (1/105) \cdot [(2450 - 20) \cdot (1420 - 1200)] = 4.6$ MPa

$P_2 = 0.0012450 + 1.6 = 4.1$ MPa.

Pmax = 4.6 + 4.1 = 8.7 MPa.

For a column with a diameter of 146 mm:

$P_1 = (1/105) \cdot [(4500 - 20) \cdot (1420 - 1200) = 9.8$ MPa

$P_2 = 0.001\ 4500 + 1.6 = 6.1$ MPa.

$P_{max} = 9.8 + 6.1 = 15.9$ MPa.

2.6.6 Calculation of the number of cementing aggregates

The number of cementing aggregates will be determined based on the condition for obtaining the rate of lifting of the cement slurry in the annular space at the casing shoe at the time of the start of pumping (at least 15 m / s for the surface

conductor and intermediate strings, less than 1.8 - 2.0 m / s for production strings); This condition follows from the assumption that an increase in the speed of movement of the cement slurry in the annulus contributes to a more complete displacement of the clay slurry and its replacement with cement slurry.

Often, the wellbore is curved, has local expansion, and the string is not strictly cemented in it. In such cases, it is advisable to displace the cement slurry from the column, maintaining a low rate of rise of the cement slurry in the annulus (ω = 0.1-0.4 m / s). The same should be done if the column is well centered, but it is impossible to create a turbulent flow of the cement slurry in the annulus. Since the squeezing almost always starts at the highest speed (as a rule, at IV), the number of aggregates from the condition of ensuring the speed (m v / s) of the cement slurry rise in the annulus is determined by the formula:

$$N_{ts.a} = [0.785 \cdot K_1 \cdot (D^2 - d_1^2) \cdot \omega / Q_{IV}] + 1, \quad (31)$$

where Q_{IV} is the productivity of the cementing unit at IV speed, m^3 / s.

We select a cementing unit of the TsA-320M type with 127-mm cylinder bushings installed in its 9T pump (these bushings can be operated at p_{max} at the end of cementing). The maximum productivity is 0.9 m^3 / min at a pressure of 6.1 MPa.

For a column with a diameter of 324 mm:

$n_{c.a} = [0.785 \cdot 1.2 \cdot (0.3937^2 - 0.324^2) \cdot 1.5 / 60] + 1 = 2$ units.

We accept $n_{ts.a.} = 2$ unit.

For a column with a diameter of 245 mm:

$n_{c.a} = [0.785 \cdot 1.2 \cdot (0.2953^2 - 0.245^2) \cdot 1.5 / 60] + 1 = 3$ units.

We accept 4 units.

For a column with a diameter of 146 mm:

$n_{c.a} = [0.785 \cdot 1.2 \cdot (0.2159^2 - 0.146^2) \cdot 2 / (0.9 / 60)] + 1 = 6$ aggregates.

We accept $n_{ts.a} = 6$ units TsA-320M.

2.6.7 Calculation of cementing performance

Cementing productivity (duration of the cementing process in minutes) can be determined by the formula:

$t_{ts} = [(V_1 / Q_{ts}) + ((V_{ts} + V_{pr} - V_1) / Q_m)] + t_{sp}$. (32)

where $V_1 = V_{pr} - \Delta V$, ΔV is taken equal to 1 - 2 m^3;

Q_{tsa} - total productivity of cementing units, m^3 / min;

Q_m - productivity of cementing units, at which the most complete displacement of the drilling fluid by cement is achieved, m^3 / min.

$Q_m = 0.785 (D^2 - d_1^2) K_1 \omega$, (33)

tsp - time spent during cementing for auxiliary operations, mm (t_{sp} + 10 - 15 min.)

For a column with a diameter of 324 mm:

$Q_m = 0.785 (0.3937^2 - 0.324^2) 1.2\ 1.5 = 0.07\ m^3 / s = 4.2\ m^3 / min.$

$t_c = [(25.5 / 0.9 \cdot 2) + ((18.6+ 26.11 - 25.5) / 4.2)] + 10 = 22.6$ min.

For a column with a diameter of 245 mm:

$Q_m = 0.785 (0.2953^2 - 0.245^2) 1.2\ 1.5 = 0.04\ m^3 / s = 2.4\ m^3 / min.$

$t_c = [(103.39 / 0.9 \cdot 4) + ((60.9+ 104.39 - 103.39) / 2.4)] + 10 = 81.7$ min.

For a column with a diameter of 146 mm:

$Q_m = 0.785 (0.2159^2 - 0.146^2) 1.2\ 1.5 = 0.048\ m^3 / s = 2.88\ m^3 / min.$

$t_c = [(63.1 / 0.9 \cdot 6) + ((73.25+ 131.6 - 63.1) / 2.88)] + 10 = 60.9$ min.

Duration of cementing should not exceed 75% of the time of the onset of setting of the cement slurry. Then the permissible cementing time is:

$t_{dop} = 0.75\ t_{n.scmin.} = 0.75\ 120 = 90$ min.

Thus, the selected number of cementing units and the calculations performed satisfy the conditions for cementing the casing strings [6].

2.6.8 Calculation of the number of cement mixing machines

Based on the condition of providing cement mortar for all operating CA-320 M units,

$n_{tscm} = n_{tsa} Q_{tsa} / Q_{tscm}$ (34)

where Q_{tsa} is the average productivity of one operating unit when pumping cement slurry into the column, m^3 / min;

Q_{tsm} - average productivity of one cement mixing machine 2SMN-20, m^3 / min.

Based on the conditions for placing the cement powder delivered to the drilling rig in the bunkers of mixing machines:

$$n_{tscm} = Q_{ts1} / q_{tsb}, \quad (35)$$

where Q_{ts1} is the weight amount of dry cement delivered to the drilling site, taking into account the estimated losses, t;

q_{tsb} - the weight amount of cement placed in the hopper of one cement mixing machine

For a column with a diameter of 324 mm:

$n_{tscm} = 13.6 / 20 = 0.7 = 1$ machine 2SMN-20.

For a column with a diameter of 245 mm:

$n_{tscm} = 98.3 / 20 = 4.9 = 5$ machines 2SMN-20.

We accept 5 cement mixing machines 2SMN-20.

For a column with a diameter of 146 mm:

$n_{tscm} = 88.9 / 20 = 4.4 = 5$ machines 2SMN-20.

We accept 5 cement mixing machines 2SMN-20

2.6.9 Cementing Equipment

Cementing aggregates

Cementing units are designed:

– for preparation, injection and squeezing of grouting (or other) solutions into wells;

– for carrying out various types of well flushing through lowered pipe strings;

– for treatment of the bottomhole zone of wells, injection of isotope solutions, carrying out hydrosand-jet perforation and other technological operations in wells;

– for pumping various liquids or solutions from tanks of wells and reservoirs;

– for hydraulic pressure testing of casing pipes and strings, as well as various equipment.

The most widespread in the deposit practice of oil and gas regions of the country are cementing units TsA-320M and ZTSA-400A.

Cementing units TsA-320M will be used for cementing the project well.

Technological characteristics of the cementing unit TsA-320M:

Mounting base …….. KrAZ-257 vehicle chassis

Cement pump:

type …… .9T

hydraulic power, HP ……...125

piston stroke, mm ……. …… .250

maximum pressure, kgf / cm^2 ……..……. 320

maximum flow rate, l / s ……..…… . 23

drive …… .. …… from the engine of the KrAZ-257 vehicle

water supply pump:

type ……..…… .. 1B

plunger diameter, mm ……..…… ..125

plunger stroke, mm ……..…… ..170

flow rate, l / s …… 13

pressure, kgf / cm^2 ……..…… .15

drive …… from the GAZ-51A engine

measuring tank capacity, m ……..……..6,4

cement tank capacity, m ……..… ..0.25

diameter of intake pipelines, mm …… …….. …… .100

diameter of discharge pipelines, mm ……..… ..50

total length of the dismountable pipeline, m …… 22

Total weight of the unit, t ……..…… . 17.5

Cement mixing machines

Cement mixing machines and units are designed for transportation of dry grouting materials (clay powders) and mechanized preparation of grouting (clay) solutions.

In deposit practice, cement mixing machines 2SMN-20, SMP-20, SM-10, SM-4M and units 1AS-20, 2AS-20, ZAS-30 are used.

In this case, cement mixing machines 2SMN-20 will be used.

Technical characteristics of the machine 2SMN-20:

Mounting base …….…… .. KrAZ-257 vehicle chassis

Transport capacity, t ……..…… .8 - 10

Hopper volume, m ……. …… .14.5

Hopper capacity (for cement), t ……..… .. …… .20

Method of obtaining solution …… .. ……..…… mechanical-hydraulic

Productivity in m / min during cooking:

Cement mortar ……..…… 0.6 - 1.2

Cement-bentonite mortar ……..… .0.5 - 1.0

Clay mortar …… .1.0 - 2.0

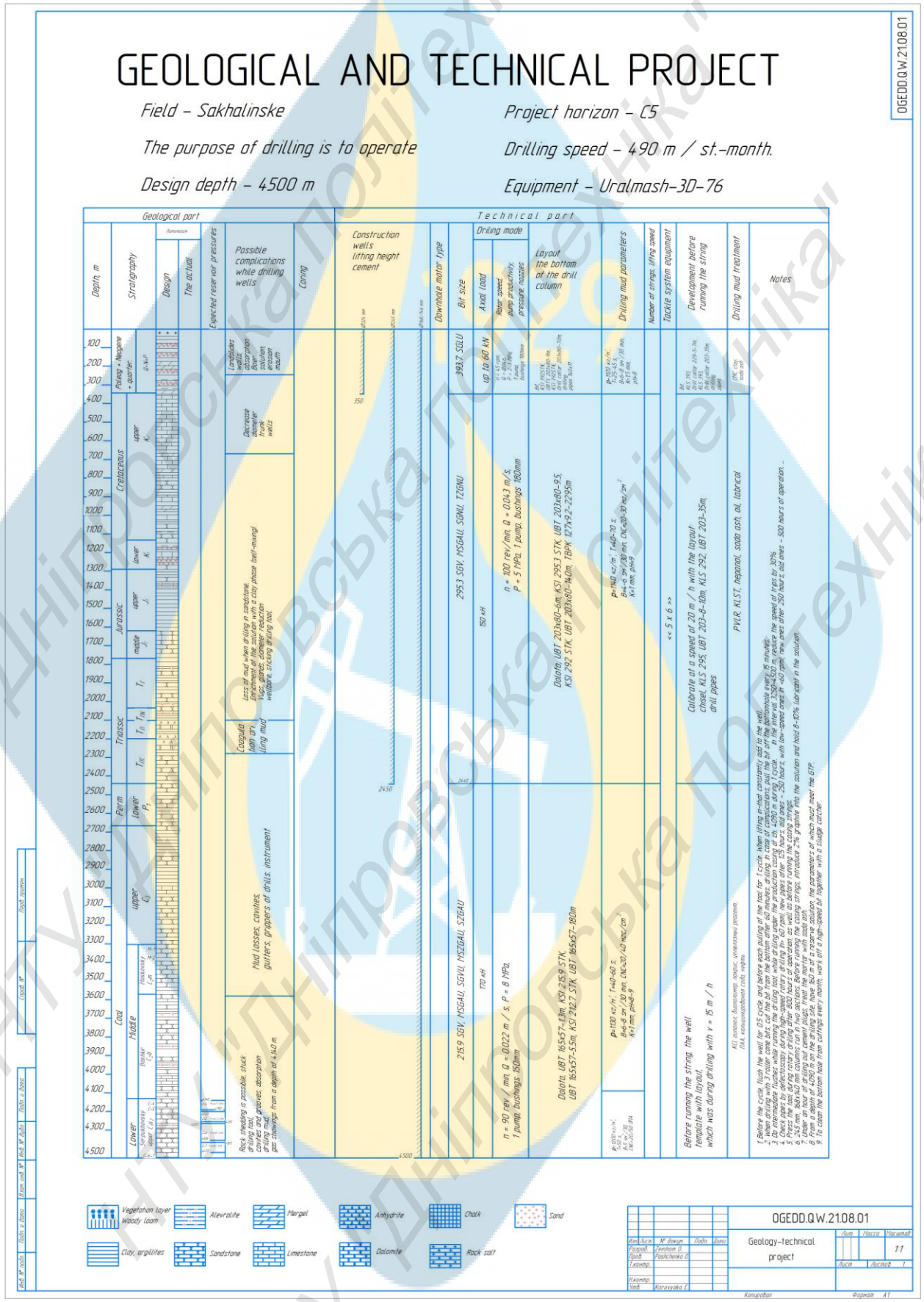
Mixing fluid pressure, kgf / cm^2 …… .8 - 20

Total weight of the unloaded machine, t …… 13.8

Method of loading into the bunker ……..… . by auger loader

The density of the grouting slurry is regulated by changing the amount of water supplied to the mixer using a device with a set of nozzles and a tap on the bypass line, as well as the amount of dry cement supplied by changing the rotation speed of the motor shaft and two parallel loading augers located in the bottom of the 2SMN-20 hopper [7].

According to the above material, a geological and technical project has been developed (Fig.3.2).



Conclusions for the section

The well will be drilled by a drilling rig Uralmash-3D-76 in three drilling intervals: conductor - 324 mm in diameter, intermediate string - 245 mm in diameter and for production casing 168/146 mm in diameter. The drilling process is monitored by the GTI station. Cementing of the well will be carried out using cement mixing machines 2SMN-20, cementing units and a blending tank. Control of the process will be provided by the SKTs-2M cementing control station.

3 LABOUR PROTECTION

3.1 Main regulatory documents

Well drilling must be carried out in compliance with the requirements of the Law of Ukraine “On Amendments to the Law of Ukraine” On Labor Protection”, approved by the VRU No. 229-IV on November 21, 2002; The Law of Ukraine “On Fire Safety”, approved by the VRU No. 3747-XII on December 17, 1993; The Law of Ukraine “On Oil and Gas”, approved by the Verkhovna Rada of Ukraine, 12.07.01 No. 2665-III; The Law of Ukraine “On objects of increased danger”, approved by the VRU, 18.01.01 No. 2245-III, the Law of Ukraine “On ensuring the sanitary and epidemiological well-being of the population”, approved by the VRU on 01.24.94 No. 4004-XII; the Land Code of Ukraine, approved by the VRU on 25.10.01 No. 2196-XII; the Water Code of Ukraine, approved by the VRU on 06.06.95 No. 213/95-VR; to the Labor Code of Ukraine, approved by the VR Ukrainian SSR 10.12.71 # 322 - VIII; the Code of Ukraine on Subsoil, approved by the VRU, 27.07.94 # 132/94-VR; Resolutions of the Cabinet of Ministers of Ukraine "On the approval of the list of objects and individual territories that are subject to constant and mandatory maintenance by state emergency services" dated 04.08.00 No. 1214, the Law of Ukraine "On compulsory state social insurance against industrial accidents and occupational diseases that caused the loss of operability ", approved by the ASU on September 23, 1999 No. 1105 - XIV and adopted in accordance with them by intersectoral and sectoral regulations on labor protection, industrial sanitation and fire safety, the observance of which is mandatory during the construction of a well dated 04.08.00 No. 1214, the Law of Ukraine “On Compulsory State Social Insurance against Industrial Accidents and Occupational Diseases That Caused the Loss of Working Capacity”, approved by the VRU No. 1105-XIV on 23.09.99, and the intersectoral and sectoral normative acts adopted in accordance with them on labor protection, industrial sanitation and fire safety, compliance with which is mandatory during well construction dated 04.08.00 No.

1214, the Law of Ukraine “On Compulsory State Social Insurance against Industrial Accidents and Occupational Diseases That Caused the Loss of Working Capacity”, approved by the VRU No. 1105-XIV on 23.09.99, and the intersectoral and sectoral normative acts adopted in accordance with them on labour protection, industrial sanitation and fire safety, compliance with which is mandatory during well construction.

3.2 Basic requirements for labour protection

Persons at least 18 years of age who have undergone a medical examination in order to determine their physical condition and meet the requirements of this profession and have no contraindications for health reasons for working in their specialty according to DNAP 0.03-8.06-94 can be allowed to work related to the construction of a well. DNAOP 0.03-8.07-94, DNAOP 0.03-8.08-93, and also passed occupational safety training in accordance with the requirements of DNAOP 0.00-4.12-99.

It is forbidden for women to work in professions with harmful and difficult working conditions in accordance with Art. 10 of the Law of Ukraine “On labor protection” and DNAP 0.03-8.08-93. In accordance with the certification of workers carried out in accordance with the requirements of the Cabinet of Ministers of Ukraine dated 01.08.92 No. 442 "On the procedure for certification of workplaces for working conditions", women are allowed to work as a laboratory collector to work related to the construction of a well.

According to Art. 7 of the Law of Ukraine “On labor protection” and certification of workplaces, workers of rig and drilling crews engaged in work with difficult and hazardous working conditions should be provided with the right to an old-age pension on preferential terms according to list No. 2 according to the Resolution of the Cabinet of Ministers of Ukraine dated 09/01/92 No. 41 and 7 additional days to the general vacation in accordance with the Law of Ukraine "On Vacations".

Workers of the drilling crew, as well as maintenance personnel working on heavy robots, robots with harmful or dangerous working conditions or those that require professional selection, must undergo a periodic medical examination in accordance with the “Regulations on the medical examination of workers of certain categories”, approved by order of the Ministry of Health of Ukraine on 03/31/94 No. 45 in accordance with additions 1, 2 to the order of the Ministry of Health of the USSR 09.29.89 No. 555, Resolutions of the Cabinet of Ministers of Ukraine: “On mandatory preventive drug treatment and the procedure for its conduct” dated 06.11.97 No. 1238, On approval of the Procedure for conducting mandatory previous and periodic psychiatric reviews and a list of medical psychiatric contraindications regarding the performance of certain types of activities (work, profession, service) that may pose an immediate danger to a person,

It is forbidden to admit workers to work in the event of an unsatisfactory conclusion (lack thereof) of the medical commission regarding the possibility of continuing to work in their profession.

To ensure the fulfillment of safety requirements and control of the state of labor protection in the department, responsible officials for the state of labor protection must be appointed. Obligations to ensure the normative state of labor protection should be established in accordance with the requirements of the Law of Ukraine “On labor protection”, “Unified labor protection management system in the oil industry”, approved by order of Derzhnaftoprom "dated 05.16.96. No. 76, “Directory of qualification characteristics of workers’ professions” Issue 1, approved by the order of the Ministry of Labor and Social Policy of Ukraine dated February 16, 1998 No. 24 and issue 6 dated July 28, 1999. On the basis of the above-mentioned regulations, the job descriptions of the employees of the department should contain the displayed duties regarding labour protection.

In order to carry out preventive measures aimed at eliminating harmful and dangerous production factors, preventing industrial accidents, occupational diseases and other cases of threats to the health of the insured caused by working conditions; restoration of health and working capacity of victims at work from accidents

or occupational diseases; compensation for material and moral harm to the insured and their family members, to carry out the necessary types of social insurance and provide, if necessary, other types of insurance.

During well construction, the following measures must be taken to protect workers from injury:

General requirements:

- equipment of the drilling rig, workplaces, as well as the territory of the drilling rig must be provided with the necessary posters and safety signs defined in the “Unified List of Mandatory Minimum Posters on Safety on a Deep Drilling Rig”, approved by the Deputy Minister of Oil Industry of the USSR in 28.11.88, and GOST 12.4.026-76 SSBT “Signal colours and safety signs”; GOST 12.2.061-81 SSBT “Production equipment. General safety requirements for workplaces”;
- the rig equipment must meet the requirements of GOST 12.2.003-91 SSBT “Production equipment. General safety requirements” and GOST 12.2.041-79 SSBT “Drilling equipment. Safety requirements”, as well as the requirements of passports or operating documentation.
- fencing of moving mechanisms of drilling equipment, which pose a danger to workers, must ensure compliance with the requirements of GOST 12.2.062-81 SSBT “Production equipment. Protective fences” and section 5.4. DNAP 1.1.21-1.20-03.
- installation, adjustment, testing and operation of the drilling rig electrical equipment should be carried out in accordance with the requirements of DNAP 0.00-1.21-98, PUE, DNAP 0.00-1.32-01, DNAP 1.1.10-1.07-01.
- to ensure the safety of people, metal parts of electrical installations, electrical equipment housings and drive equipment must be made in accordance with clause 5.5.12 DNAP 1.1.21-1.20-03 and grounded, neutralized in accordance with the requirements of PUE, DNAP 0.00-1.32-01 and DNAP 1.1.10-1.07-01.

- Loading and unloading operations should be carried out taking into account the requirements of DNAP 0.00-1.03-02 and the instructions for labor protection and operation of loading and unloading mechanisms developed in accordance with them in the management.

When performing construction and installation work, it is necessary:

- adhere to the requirements of the technical rules “Construction and installation of drilling rigs”, approved by the deputy. gen. director of VO “Ukrnafta” in 20.07.78, Kiev in 78, technical conditions "Construction and installation of drilling rigs, TU” shut. deputy. gen. Director of the VO “Ukrnafta” 1974, Kiev in 1975
- to carry out them taking into account the safety requirements specified in the “Project for the organization of work on the installation and dismantling of the drilling rig” developed, agreed and approved in the prescribed manner by the drilling department. The project is being developed on the basis of the “Project for the organization of works on installation and dismantling of drilling rigs BU 5000 EU, BU 5000 DGU, BU 2500 EU (EP), BU-4E (approved by “Ukrgazproniineft”in 10.12.1991).
- Before carrying out construction and installation works, it is necessary to prepare the site for the installation of the drilling rig in accordance with clause 3.1.2 of the PPB in the oil industry.
- the placement of drilling equipment should be carried out in accordance with the “Layout of drilling equipment” developed, agreed and approved in the prescribed manner by the drilling department, on the basis of the “Unified layouts of drilling equipment” (specified in the TU), taking into account the equipment on the site.
- during construction, pulling, dismantling of the drilling rig, pulling blocks, it is necessary to adhere to the requirements of “Measures for safe construction, pulling (collection), dismantling of the drilling rig, pulling blocks” developed, agreed and approved in the manner established by management,

taking into account the above and other regulations on labour protection and fire safety.

When drilling a well:

- drilling of a well can only be started after the drilling rig is put into operation, which is carried out in accordance with cl. 6.1.1., 6.5.1. DNAP 1.1.21-1.20-03.
- drilling of a well must be carried out in accordance with the regulatory enactments on labor protection issues defined in Table 1, in particular, section 6 DNAP 1.1.21-1.20-03, section 7 NAPP 1.1.21-1.18-82, as well as instructions from the security department in force labor by profession and type of work.
- drilling of a well must be carried out in compliance with the requirements of the "Collection of Instructional Maps of Advanced and Safe Work Practices when Drilling Wells" developed by CNED and approved by the Deputy Chairman of the Board for Drilling in 01.07.04.
- to prevent gas and oil water seepage and open well flowing, wellhead piping and work should be carried out in accordance with Section 6.6. DNAP 1.1.21-1.20-03, section 6 NAP 1.1.21-1.18-82, as well as SOU 11.1-00135390-004: 2004 "Arrangement of the mouth of oil and gas wells of air defense. Typical wellhead connection schemes, rules for performing work" developed by Poltava by the paramilitary unit of OJSC "Ukrnafta" and commissioned on 01.07.2004; developed, agreed and approved in accordance with the established procedure by the drilling department "Measures for accident-free drilling of wells".

Upon completion, development and performance of technological operations that accompany the process of well construction:

- well casing should be carried out in accordance with the work plan approved by the management (agreed with the customer) in compliance with the requirements of section 6.4. DNAP 1.1.21-1.20-03, section 13 of NAPP

1.1.21-1.18-82. When running the casing string, it is necessary to adhere to the above listed regulations on labor protection, as well as the requirements of the “Instructional map of advanced and safe working practices when running casing strings using a spider-elevator, a hydraulic power switch” Rutherford “and PKRO” developed by CNED, approved by the Deputy Chairman of the Board for Drilling in 04.12.2003

- well development should be carried out in accordance with the work plan approved by the management (agreed with the customer) in compliance with the requirements of section 6.8. DNAP 1.1.21-1.20-03, section 14 of NAPP 1.1.21-1.18-82.
- during geophysical, perforating and blasting operations, it is necessary to adhere to the requirements of Section 8. DNAP 1.1.21-1.20-03, Section 12 NAPP 1.1.21-1.18-82.
- during the carrying out of compatible works, it is necessary to comply with the requirements of the “Regulations on the organization of safe work at facilities by several enterprises (workshops) of OJSC Ukrnafta”, approved by the order of OJSC “Ukrnafta” dated 30.09.1999 and works at the facilities of the Prilutsky UBR”.
- scheduled preventive maintenance (PPM) and current repair work should be carried out according to the schedules, in accordance with the “Regulations on the procedure for organizing and conducting scheduled preventive maintenance of drilling and power equipment” and “Regulations on the safe procedure for conducting repair and preventive maintenance of drilling and power equipment”.

3.3. Industrial sanitation

To ensure the normative sanitary and epidemiological state in the department, responsible officials should be appointed for the sanitary and epidemiological state and in the deposit of waste management. Obligations to ensure the norma-

tive sanitary and epidemiological state should be established in accordance with the requirements of the Law of Ukraine “On ensuring the sanitary and epidemiological well-being of the population”, the Law of Ukraine “On Waste”, and policy of Ukraine from 16.02.98, No. 24, and issue 6 from 28.07.99.

Workers of drilling crews, as well as maintenance personnel must be provided with personal and collective protective equipment from hazardous and harmful factors of the working environment in accordance with the “Standard Industry Standards for Free Issuance of Overalls, Safety Shoes and Second Personal Protective Equipment to Employees of Oil and Gas Industry Enterprises” DNAOP 0.05-3.24-80 and “Industry norms of free distribution of overalls, special footwear and second personal protective equipment”, approved 1979-1981r. The USSR State Committee for Labor and Social Affairs (the necessary personal protective equipment is shown in Table 5.4). The required number is determined in accordance with the above-mentioned normative acts and the “Collective Agreement”.

The drilling crew must be provided with the necessary sanitary facilities (the list is given in Table 3.1). Household and recreational facilities must meet Sheaf 2.09.04-87.

Workers engaged in work related to the construction of a well should be provided with free soap and neutralizing agents in accordance with DNAP 0.05-3.06-22 “On the issuance of soap at enterprises”, approved by the resolution of the People's Commissariat of Labor (NKP) of the RSFSR dated 06.08.22 and clarifications on this issue of the NKP of the USSR from 22.06.24 and 14.04.26.

The procedure for providing workers with overalls, special footwear and other personal protective equipment is determined by the “Regulations on the procedure for providing employees with special clothing, special shoes and other personal protective equipment”, approved by order of the State Committee of Ukraine for the supervision of labor protection dated October 29, 1996 No. 170.

The level of noise and vibration at workplaces must be within the permissible limits specified in GOST 12.003-76 and SN 245-71. According to the intentions carried out (Research work “Study of noise and vibrations at drilling rigs and

development of recommendations and measures to reduce them" carried out by the Ivano-Frankovsk Institute of Oil and Gas, in 1979 the results of certification of workplaces, CNED JSC Ukrnafta) determined the excess of the permissible the noise level in the power and pumping units. Due to the fact that they cannot be reduced, which is associated with the technological process of drilling the well and the existing type of equipment, it is necessary to use individual anti-noise headphones in the power and pump rooms. At other workplaces it is necessary to use earplugs (see Table 3.1).

Table 3.1 - Sanitary facilities

No. p / p	Name, type, type, code, etc.
1	2
1	Cabin-car (cultural booth) with a master's office and a rest room, equipped with heating and cooling devices, a washbasin, a drinking water tank
2	Cabin carriage with a dressing room, a dryer for workwear and shoes
3	Cabin wagon with shower
4	Canteen carriage for 8 seats
5	Housing wagon houses - 5 pcs.
6	External dressing room, made in the form of a wooden booth with a cesspool with one sanitary hole

The level of noise and vibration at workplaces must be within the permissible limits specified in GOST 12.003-76 and SN 245-71. According to the intentions carried out (Research work "Study of noise and vibrations at drilling rigs and development of recommendations and measures to reduce them" carried out by the Ivano-Frankovsk Institute of Oil and Gas, in 1979 the results of certification of workplaces, CNED JSC Ukrnafta,) determined the excess of the permissible the noise level in the power and pumping units. Due to the fact that they cannot be reduced, which is associated with the technological process of drilling the well and

the existing type of equipment, it is necessary to use individual anti-noise headphones in the power and pump rooms. At other workplaces it is necessary to use earplugs (see Table 3.1).

The level of illumination and its implementation at the drilling site must meet the requirements of PUE, DNAP 0.00-1.32-01 and building codes and regulations established by SN 245-71, ONTP 51-1-85 and Sheaf II-4-79.

Industrial waste, garbage, scrap metal must be removed in a timely manner and accumulated in specially designated areas. Waste removal should be carried out by special transport, in accordance with the requirements of the developed, agreed and approved in the prescribed manner "Instructions on the collection, temporary storage and transportation of industrial waste, containment and rules of hygiene and labor protection in the process of handling them" in accordance with the requirements of DsanPiN 2.2.7.029- 99 "Hygienic requirements for the handling of industrial waste and the definition of their hazard class for public health."

3.4 Fire safety

Employees who take part in the construction of a well, as well as officials, can be allowed to work after training and testing knowledge on fire safety issues (the list is defined in the “List of positions, upon appointment to which persons are required to undergo training and knowledge testing on fire safety issues.) safety and the procedure for their organization” approved by order of the Ministry of Emergency Situations of Ukraine dated 09.29.2003 No. 368) in accordance with the “Typical provision on instructions, special training and knowledge testing on fire safety issues at enterprises, institutions and organizations of Ukraine”, approved by order of the Ministry of Emergency Situations of Ukraine dated 09/29/2003 No. 368 (z1147 - 03).

In order to ensure fire safety in the drilling operations department, responsible officials should be appointed for fire safety, maintenance and operation of technical fire protection equipment. Obligations to ensure the normative state of fire safety should be established in accordance with the requirements of the Law of Ukraine

“On Fire Safety”, NAPB A.01.001-2004, NAPB B.01.027-85 / 112 and the “Directory of the qualification characteristics of workers’ professions” Issue 1, approved by order of the Ministry labor and social policy of Ukraine dated 16.02.98, No. 24 and issue 6 dated 28.07.99. On the basis of the above-mentioned regulations, the job descriptions of UBR employees should contain the displayed responsibilities for ensuring fire safety,

Fire safety during well construction must be organized in accordance with the requirements of the Law of Ukraine “On Fire Safety”, NAPB A.01.001-2004 “Fire Safety Rules in Ukraine”, NAPB B.01.027-85 / 112 “Fire Safety Rules in the Oil Industry”, DBN V.1.1-7-2002 “Fire protection. Fire safety of construction facilities”,“Fire safety rules in forests”, DBN 360-92 “Urban planning. Planning and development of urban and rural settlements”, SNiP 89-80 “General plans of industrial enterprises”, GOST 12.1.004-91 “Fire safety. General requirements", GOST 12.4.009-83” Fire fighting equipment for object protection. Main types. Accommodation and maintenance” and other applicable fire safety regulations.

The drilling room must be equipped with primary certified fire extinguishing means (fire extinguishers, fire hoses, trunks and hydrants) in accordance with the requirements of Appendix 3 NAPB A.01.001-2004, Supplement 21 NAPB B.01.027-85 / 112. Quality certificates (or copies thereof) for primary fire extinguishing equipment must be kept at the rig.

Hot work must be carried out in accordance with the “Instruction from the organization of safe conduct of hot work at explosive and explosive objects” developed, agreed and approved in the prescribed manner by the drilling management on the basis of the "Instruction from the organization of safe conduct of hot work at explosive and explosive objects", approved by order of the Ministry of Labor and Social Policy of Ukraine dated 06.06.2001 No. 255, as well as taking into account the explosive zones of the drilling rig.

Conclusions for the section

In the section provides all the necessary life safety measures.

4 SUBSOIL AND ENVIRONMENTAL PROTECTION

4.1 Sustainability of the project

Environmental measures must comply with the requirements and regulations, state standards for environmental protection.

4.2 Sources of pollution and types of environmental impact

a). The main sources of environmental pollution during hydraulic fracturing: hydraulic fracturing fluids; combustible lubricants (fuels and lubricants); fuel combustion products during operation of internal combustion engines; household liquid and solid waste; contaminated storm water.

b). Types of possible impact on the environment during hydraulic fracturing:

contamination with hydraulic fracturing fluids and chemicals used in the composition of fluids for hydraulic fracturing, fuels and lubricants: soil, surface water bodies, atmospheric air.

c). Possible targets: soil; bosom; surface water bodies; atmospheric air; Flora and fauna.

4.3 Environmental protection measures during hydraulic fracturing

The use of oil-based compositions, which are treated with CLEARWATER Inc. reagents, is envisaged as fluids for hydraulic fracturing. According to the company, most of the reagents used are roughly 2-3 hazard class. In addition, the basis of the composition of the substance of the 3rd class of toxicity, which poses a potential hazard to the environment. In this regard, the main environmental measure during hydraulic fracturing is to exclude the possibility of penetration of fracturing fluid into the environment, which is achieved by the following measures:

- to prevent liquid spillage during assembly and disassembly of communications, portable containers (pallets) are installed under fittings and quick-detachable pipe connections;

- preparation of hydraulic fracturing fluids is carried out using a technology that excludes the ingress of its components into the soil;

- it is prohibited to carry out hydraulic fracturing in wells with leaking casing and, accordingly, with behind-the-casing flows.

4.4 Emergency situations

Many well pads are located in difficult natural and climatic conditions. In our area of oil production, swampiness and water flooding of the territory is about 70%.

An emergency situation is a state in which, as a result of a source of emergency at an object or a certain territory, the normal conditions of life and activities of people are violated, a threat to their life and health arises, and damage is caused to the property of the population, the national economy and the environment. Emergencies are classified depending on the number of people affected in these situations, or people whose living conditions were violated, the amount of material damage, as well as the boundaries of the zones where the damaging factors of emergencies are spread. Emergencies are classified as local, local, territorial, regional, federal, and cross-border.

In our harsh natural and climatic conditions, during well workover, the following emergencies may arise: Natural, flood floods; forest and peat fires; hurricanes; severe frosts (below - 400); blizzards and snow drifts.

Technogenic character: open fountains; fires; explosions; power outage.

Conclusions for the section

The section describes measures to prevent accidents and complications as well as to protect mineral resources and the environment.

CONCLUSIONS

In this work, the drilling and casing of an exploratory gas well with a depth of 4500 m was designed in terms of Sakhalinsky deposit of Poltava region.

In the general part, the geographical location, an overview of previously conducted geological and geophysical studies and the geological characteristics of the area of work are given. The following is described: stratigraphy, tectonics oil and gas content of the area.

The planned well will be drilled by a drilling rig Uralmash 3D-76 in four drilling intervals: under the direction with a diameter of 426 mm, a conductor with a diameter of 324 mm, an intermediate casing with a diameter of 245 mm and under a production casing with a diameter of 168 mm, using a polymer-clay mud. The drilling process will be monitored by the GTI station. Well cementing will be carried out from the use of 5 cement mixing machines 2SMN-20, 6 cementing units and a blending capacity. Control of the process will be provided by the SKTs-2M cementing control station.

The work provides all the necessary life safety measures, considered measures to prevent accidents and complications as well as to protect mineral resources and the environment.

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APPENDIX A

List of the qualification paper materials

No.	Format	Designation	Names	Number of pages	Note
1					
2			Documentation		
3					
4	A4	OGEDD.21.05.PZ	Explains the note	71	
5					
6			Demonstration material	1	
7					
8			Graphical material	1	