

# Increasing the efficiency of extraction of residual reserves of hydrogen sulfide-containing deposits of the Uchkyr gas condensate field

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**Abstract.** This paper examines the low-sulfur gas deposit GKF Uchkyr, which has been preserved for an extended period due to the absence of sulfur removal facilities. The findings regarding the reasons for surpassing or falling behind the actual and projected development indicators are outlined. Additionally, the results of geological and geophysical studies, along with the factors contributing to the insufficient volume of research, are presented. To organize control over the development of a gas field, the correct choice of parameters characterizing the state of the deposit during its development is important. In this case, must be observed conditions that ensure systematic monitoring of changes in selected parameters and assessment of measurement error. These parameters are: reservoir pressure in the gas and aquifer parts of the deposit, gas saturation coefficient of the developed formation, ion-salt composition of the water produced by gas wells. Considering the information above, recommendations are provided to facilitate timely monitoring of changes in technological development indicators and to enhance the efficient extraction of hydrocarbons from the productive horizons of the GKF Uchkyr deposit.

## 1 Introduction

The Uchkyr gas condensate field is located 45 km west of Gazli city and 180 km northwest of the Kagan railway station. The Central Asia-Center gas pipeline runs directly across the field area; in addition, the field is connected to connecting gas pipelines and to the Gazli headworks. The field was discovered in 1960, exploration work was completed in 1973. In 1968, the Uchkyr deposits of sulfur-free gas were put into pilot production. This paper examines the low-sulfur gas deposit of the XV horizon (XV-1, XV-2) of the Uchkyr gas condensate field, which was mothballed for a long time (1966-1979) due to the lack of desulfurization facilities.

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This deposit was put into development in December 1979, according to the «Project for the development of gas deposits of the XV horizon of the Uchkyr field» [1]. In subsequent research projects (1982, 1997, 2005, 2007), adjustments were made to the technological indicators of field development.

Productive horizons XV-1 and XV-2 are confined to carbonate deposits of the Upper Jurassic (Middle Callovian-Oxfordian + Kimmeridgian), composed of dolomites and limestones with interlayers of anhydrites, siltstones and sandstones [2].

The reservoir rocks that make up the XV-1 and XV-2 horizons are similar in their lithological and physical properties. The average values of porosity, permeability and gas saturation coefficient based on the results of laboratory studies of cores from the XV-1 and XV-2 horizons are presented in table 1.

**Table 1.** Average values of porosity, permeability and gas saturation coefficient of XV-1, XV-2 horizons of the Uchkyr gas condensate field.

Properties	Number of core samples		Average value	
	XV-1 horizon	XV-2 horizon	XV-1 horizon	XV-2 horizon
Open porosity, %	51	17	17.55	16.10
Permeability, m Darcy	50	15	10.3	6.27
Gas saturation coefficient	28	3	0.586	0.487

## 2 Methods and materials

According to field geophysical studies, the arithmetic average values of open porosity are slightly lower (for the XV-1 horizon - 16.4%, for the XV-2 horizon - 14.1%), and the gas saturation is higher and is 62% for the XV-1 horizon, along the XV-2 horizon – 66% [2].

The gas of the XV-1 and XV-2 horizons are hydrogen sulfide-carbon dioxide-hydrocarbon, dry and light. The hydrogen sulfide content in the reservoir gas increases from the XV-1 to the XV-2 horizon, while the carbon dioxide content, on the contrary, decreases. The potential content of stable condensate is taken to be 33.6 g/m<sup>3</sup> [2]. To organize control over the development of a gas field, the correct choice of parameters characterizing the state of the deposit during its development is important. In this case, must be observed conditions that ensure systematic monitoring of changes in selected parameters and assessment of measurement error. These parameters are: reservoir pressure in the gas and aquifer parts of the deposit, gas saturation coefficient of the developed formation, ion-salt composition of the water produced by gas wells. Control over field development is carried out by conducting a complex of gas-hydrodynamic, geophysical and hydrochemical studies in production and control (observation, piezometric) wells [3].

The task of gas-hydrodynamic studies [4] of wells is to determine their productive characteristics, and the obtained results are the basis for project development when determining the number of wells [4].

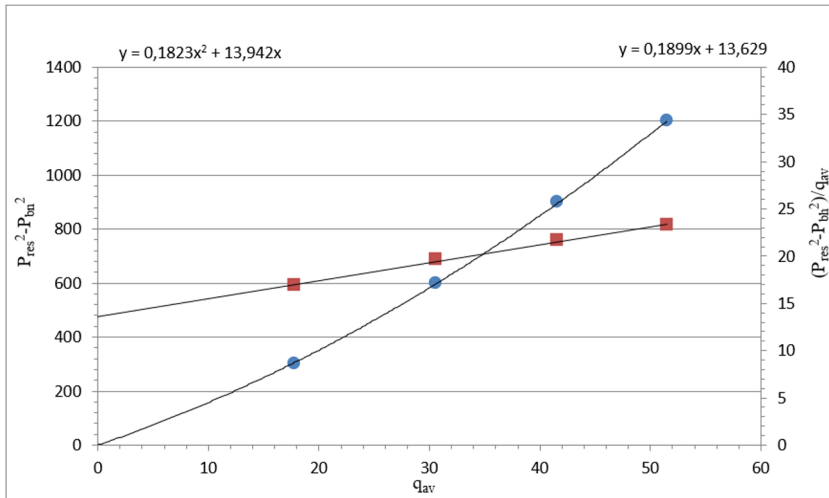
Additionally, based on the results of hydrodynamic testing, adjustments are made to the project development indicators and the appropriate technological well operation mode is established [3]. In order to control the development of natural gas fields, hydrodynamic testing is envisaged once a year across the entire existing well stock [3]. In most wells of the Uchkyr gas condensate field, hydrodynamic testing was carried out in insufficient volume and in a limited number of modes; there are no measurements of the removal of fluid from well production and mechanical impurities, and measurements of casing pressure are not provided [5].

In order to average the filtration resistance coefficients for the period of development of the considered XV horizon, due to the insufficient number of well tests, we used earlier

information on wells (Table 2, Figure 1). To calculate the indicators (Table 2, Figure 1) of the development, the following filtration resistance coefficients can be accepted:  $A_{av} = 11,3$ ;  $B_{av} = 0,1629$ .

**Table 2.** Results of averaging of filtration resistance coefficients of wells of the XV horizon of the Uchkyr field.

No. of well	Research date	Filtration resistance coefficients		Gas flow rate at $\Delta P^2$ , thousand $m^3/day$			
		A	B	300	600	900	1200
2A	06.11.2014	89.1	0.6138	3.3	6.4	9.5	12.4
103	24.09.2007	9.6	0.2147	21.2	35.1	46.2	55.7
201	19.04.2007	4.1	0.2065	29.4	44.8	56.8	66.9
202	19.12.2006	7.0	0.3587	20.7	32.3	41.3	48.9
203	27.03.2007	4.1	0.2030	29.7	45.3	57.4	67.6
204	08.08.2017	25.4	0.1690	11.0	20.8	29.6	37.8
205	16.04.2008	3.2	0.2035	31.4	47.0	59.2	69.4
206	25.09.2007	5.3	0.4440	20.7	31.2	39.4	46.3
207	21.12.2006	5.4	0.3389	22.9	34.9	44.2	52.1
208	23.08.2017	25.5	0.6299	9.5	16.7	22.6	27.9
209	24.08.2017	12.4	0.0949	20.9	37.6	51.9	64.7
210	01.08.2017	8.5	0.1176	26.0	43.9	58.5	71.1
211	16.08.2017	5.1	0.0816	37.0	60.0	78.3	94.0
212	10.10.1995	18.9	0.0550	15.2	29.3	42.4	54.8
213	15.08.2017	9.2	0.0803	26.5	46.4	63.1	77.7
215	03.02.1998	7.9	0.1278	26.5	44.2	58.5	70.7
217	16.04.1996	22.8	0.0360	12.9	25.3	37.3	48.9
220	06.01.1995	16.2	0.0330	17.9	34.7	50.5	65.5
221	27.05.2008	15.0	1.2640	10.6	16.6	21.4	25.4
222	09.08.2017	21.9	0.0969	13.0	24.7	35.5	45.6
223	1997	56.2	0.3332	5.2	10.1	14.7	19.2
225	02.08.2017	23.4	0.0890	12.2	23.5	34.1	43.9
243	10.11.1999	18.6	0.0430	15.6	30.1	43.9	57.0
251	21.02.2001	12.3	0.0340	23.0	43.6	62.5	80.0
261	11.05.2007	10.2	0.0491	26.1	47.8	66.7	83.8
263	15.08.2007	6.4	0.1120	30.5	49.9	65.5	78.7
264	25.02.1997	13.9	0.0200	20.9	40.7	59.5	77.5
268	24.08.2006	3.8	0.1133	37.3	57.9	73.9	87.4
302	28.05.2008	10.5	0.2520	19.5	32.2	42.5	51.2
Average flow rate, $q_{av}$				20.6	34.9	47.1	58.0
$(P_{res}^2 - P_{bh}^2)/q_{av}$				14.6	17.2	19.1	20.7



**Fig. 1.** Averaging of filtration resistance coefficients for the period of development of the XV horizon of the Uchkyr gas condensate field.

As of January 1, 2019, the stock of the XV horizon of the Uchkyr gas condensate field includes 38 wells, including:

- Active - 13 wells (wells 103, 202, 205, 206, 208, 209, 210, 211, 213, 221, 222, 223, 225).
- In conservation, stopped due to watering, having low wellhead pressure – 19 wells (wells 2A, 33, 201, 203, 204, 207, 212, 214, 215, 216, 217, 220, 243, 251, 261, 263, 264, 268, 300).
- Piezometric – 1 well (well 262).
- 5 wells were abandoned (wells 12, 218, 253, 301, 305).

In order to further effectively develop the Uchkyr gas condensate field, it is recommended to comply with the development control requirements, according to the guiding document [3], especially to monitor changes in filtration resistance coefficients when drawing up appropriate technological operating conditions for wells. The gas condensate reservoir of the XV horizon of the Uchkyr gas condensate field has been developed since December 1979. according to the research work [1]. According to the project [1], option 1 provides for a 12-year period of constant extraction in the amount of 900.0 million m<sup>3</sup> of gas per year from the existing stock of 49 wells.

As of 01.01.2019 102.3% of the approved gas reserves were selected from the object under consideration, incl. 71.1% of condensate from its approved geological reserves was recovered [1].

### 3 Results and Discussion

According to an analysis of the dynamics of actual indicators, annual gas withdrawals do not reach project indicators until 2008, despite their adjustments in 1982. The main reason here is the lag in the number of operating wells throughout the entire period of field development under consideration.

In 1981 - 1982 The project and actual indicators of annual gas extraction are close to each other as a result of an increase in the average flow rate of wells by 2.5 times.

Exceeding actual annual selections for 2008 - 2018 was the result of adjustments to project indicators in 2005 by the number of wells and increasing their average flow rate.

Backlog in 2018 is associated with the expectation of transferring wells to compressor operation, i.e. the field operated in a regime of constant operating wellhead pressure, lag in flow rates and number of wells (13 versus 16 according to the project).

The extraction of condensate from the subsoil exceeded the design indicators [1] from 1980 to 1996, due to its higher actual potential content in the gas, in comparison with the content adopted in the project [1] - 15.5 g/m<sup>3</sup>. Reduction in condensate extraction in 1997 - 2006. due to the lag in annual gas withdrawals during this period. Excess of its selection in the period 2009-2017 associated with an increase in the potential condensate content in 2013, 2016-2017 and inaccurate distribution of the total volume of gas supplied to the Uchkyr desulfurization plant due to the lack of individual gas accounting at individual fields.

Low operating wellhead pressures in 1980-1984 were due to the excess of the average well flow rate during this period by 2.5 times. Since 1985 there is an excess of the working wellhead pressure of the project indicators, as a result of a decrease in annual gas withdrawals and the average flow rate of wells (except for 2008). Reservoir pressure throughout the development period exceeded project indicators due to low approved gas reserves [1].

Considering the above, in order to quickly monitor changes in technological development indicators and effectively intensify hydrocarbon production from the XV horizon of the Uchkyr gas condensate field, it is recommended to pay special attention to the following:

- The deposit produces residual gas reserves under well operating conditions with constant operating wellhead pressure.
- The operation of wells with the observed operating wellhead pressure depends on the general system of gas preparation and processing at the Uchkyr desulfurization plant of the group of fields developed in this region.
- To intensify the rate of gas extraction, it is necessary to transfer gas production wells to compressor operation.

At the same time, conditions are created for bringing into operation idle wells that were stopped due to low wellhead pressures.

## 4 Conclusion

- The development of the hydrogen sulfide-containing deposit of the Uchkyr gas and condensate field was carried out with deviation from the project indicators.
- Gas-hydrodynamic studies were not carried out regularly and not in full.
- To increase the efficiency of extraction of residual reserves of the hydrogen sulfide-containing deposit of the Uchkyr gas condensate field, it is recommended to establish geological and hydrodynamic control over its development [5-10].

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