MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

СӘТБАЕВ УНИВЕРСИТЕТІ SATBAYEV UNIVERSITY

Institute of geology, petroleum and mining engineering
Department of Petroleum Engineering

Zhakayeva A.S.

DIPLOMA PROJECT

Effective methods of limiting the inflow of formation water to the bottom of the well

5B070800 - Oil and gas engineering

Almaty 2021

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Insitute of Geology, Petroleum and mining engineering

Department of Petroleum Engineering

APPROVED FOR DEFENSE
Head of the Petroleum
Engineering Department
Dairov Zh.K., MSc
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DIPLOMA PROJECT

Topic: « Effective methods of limiting the inflow of formation water to the bottom of the well »

5B070800 - Oil and gas engineering

Performed by Zhakayeva A.S.

Academic Adviser Doctor of Technical Sciences, Professor
D. Zh. Abdeli.

Almaty 2021

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Дата отчета 5/10/2021
Дата редактирования ---

Метаданные

Название

Effective methods of limiting the inflow of formation water to the bottom of the well

Автор

Жакаева Акмарал

Научный руководитель

Дайрабай Абдели

Подразделение

ИГНиГД

Список возможных попыток манипуляций с текстом

В этом разделе вы найдете информацию, касающуюся манипуляций в тексте, с целью изменить результаты проверки. Для того, кто оценивает работу на бумажном носителе или в электронном формате, манипуляции могут быть невидимы (может быть также целенаправленное вписывание ошибок). Следует оценить, являются ли изменения преднамеренными или нет.

Замена букв	ß	10
Интервалы	A→	0
Микропробелы		0
Белые знаки	ß	0
Парафразы (SmartMarks)	a	4

Объем найденных подобий

Обратите внимание!Высокие значения коэффициентов не означают плагиат. Отчет должен быть проанализирован экспертом.

1.02% (1.02%) КП1	0.00% (0.00%) КП2	1.51% (1.51%) КЦ
25 Длина фразы для коэффициента подобия 2	**11225** Количество слов	**70381** Количество символов

Подобия по списку источников

Просмотрите список и проанализируйте, в особенности, те фрагменты, которые превышают КП №2 (выделенные жирным шрифтом). Используйте ссылку «Обозначить фрагмент» и обратите внимание на то, являются ли выделенные фрагменты повторяющимися короткими фразами, разбросанными в документе (совпадающие сходства), многочисленными короткими фразами расположенные рядом друг с другом (парафразирование) или обширными фрагментами без указания источника ("криптоцитаты").

10 самых длинных фраз

Цвет текста

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ И АДРЕС ИСТОЧНИКА URL (НАЗВАНИЕ БАЗЫ)	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
1	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	18	0.16 %
2	**Attraction of Foreign Investments in the Sphere of Economic Development of the Forest Resource Potential and Woodworking Industry: Institutional and Territorial Preconditions** Dzyubenko Oleksandr M.;	15	0.13 %

3	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	12	0.11 %
4	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	8	0.07 %
5	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	8	0.07 %
6	**Choosing sources of financing projects for company development** Bagit T., Saparbayev B., Tokesh G. **4/13/2018** NARXOZ (NEU) (Кафедра СЭД (ФМОП))	7	0.06 %
7	**Optical Amplifiers** Tural Dovrushov **9/9/2017** Khazar University (KU) (Universitetin rəhbərliyi)	7	0.06 %
8	**Камелов Алимжан.doc** Камелов Алимжан **5/30/2019** Atyrau State University named after Khalel Dosmukhamedov (Экология)	7	0.06 %
9	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	6	0.05 %
10	**Choosing sources of financing projects for company development** Bagit T., Saparbayev B., Tokesh G. **4/13/2018** NARXOZ (NEU) (Кафедра СЭД (ФМОП))	6	0.05 %

из базы данных RefBooks (0.13 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)	
Источник: Paperity			
1	**Attraction of Foreign Investments in the Sphere of Economic Development of the Forest Resource Potential and Woodworking Industry: Institutional and Territorial Preconditions** Dzyubenko Oleksandr M.;	15 (1)	0.13 %

из домашней базы данных (0.00 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)

из программы обмена базами данных (0.89 %)

ПОРЯДКОВЫЙ НОМЕР	НАЗВАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)

1	**Creation of methods for local environmental support in the design and construction of oil and gas wells of the Kumkol field** Камила Маратовна Маханова **6/24/2019** M.Auezov South Kazakhstan State University (ВШ Химической инженерии и биотехнологии)	62 (7)	0.55 %
2	**Optical Amplifiers** Tural Dovrushov **9/9/2017** Khazar University (KU) (Universitetin rəhbərliyi)	13 (2)	0.12 %
3	**Choosing sources of financing projects for company development** Bagit T., Saparbayev B., Tokesh G. **4/13/2018** NARXOZ (NEU) (Кафедра СЭД (ФМОП))	13 (2)	0.12 %
4	**Камелов Алимжан.doc** Камелов Алимжан **5/30/2019** Atyrau State University named after Khalel Dosmukhamedov (Экология)	12 (2)	0.11 %

из интернета (0.00 %)

ПОРЯДКОВЫЙ НОМЕР	ИСТОЧНИК URL	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)

Список принятых фрагментов (нет принятых фрагментов)

ПОРЯДКОВЫЙ НОМЕР	СОДЕРЖАНИЕ	КОЛИЧЕСТВО ИДЕНТИЧНЫХ СЛОВ (ФРАГМЕНТОВ)

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

School of geology, petroleum and mining engineering

Department of Petroleum Engineering

CONFIRM
Head of the Petroleum
Engineering Department
Dairov Zh.K.,MSc
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____

TASK
For completing the diploma project

For student Zhakayeva A.S.
Topic: « Effective methods of limiting the inflow of formation water to the bottom of the well»
Approved by the order of university rector №2131-b from 24.11.2020
Deadline for completion the work: 18.05.2021.
Initial data for the diploma project: Report on the study of the injectivity profile ofthe field X LLP "X
Summary of the diploma project: Analysis will be based upon the findings from field background research, previous work,analysis of the chemical reagent.
The list of issues to be developed in the diploma project:

a) Oilfield planning;

b) Limiting the water inflow using reagent

Recommended main literature:

1) Report on the study of the injectivity profile of the field X LLP "X

SCHEDULE

for the diploma project preparation

Name of sections, list of issues being developed	Submission deadline to the Academic adviser	Notes
Introduction, methodology	10.02.2021	Task completed
Main part, database	29.02.2021	Task completed
Results	30.03.2021	Task completed
Drilling guidelines, conclusion	18.04.2021	Task completed

SIGNATURES

Of consultants and standard controller for the completed diploma project,indicating therelevant sections of the work (project).

The section titles	Consultant name (academic degree, title)	Date	Signature
Introduction, methodology	MSc, Abdeli D.Zh.	10.02.2021	
Main part, database	MSc, Abdeli D.Zh.	29.02.2021	
Results	MSc, Abdeli D.Zh.	30.03.2021	
Normcontrol	MSc,Abdeli D.Zh.	18.04.2021	

Academic Adviser Abdeli D.Zh.

The task was accepted by student Zhakayeva A.S.

Date «18» May 2021

АҢДАТПА

Дипломдық жұмыста судың түсуіне жол бермеу және ұңғымаларға химиялық жолмен мұнай өндіру кезінде қалпына келтіру коэффициентінің жоғарылауымен, атап айтқанда, силикат-полимерлі композиция негізінде гель түзетін реагент енгізу(Х) жолдары қарастырылды . Тиімді нәтиже ретінде пилоттық сынақ Х кен орнының барлық 7-ші торында өткізіледі деп болжанған болатын, су ағындарын шектеу және гетерогенді су қоймаларының орнында ағындарын реттеудің химиялық әдістерін қолданудың қазіргі жағдайына талдау жасаңыз. судың әр түрлі көздерінің кесірінен суарылған

АННОТАЦИЯ

В дипломной работе рассматривались пути предотвращения водопритока и с последующим увеличением коэффициента извлекаемости при добыче нефти к скважинам химическим путем, а именно внедрением гелеобразующего реагента на основе силикатно-полимерного состава (X). Было принято, что более эффективного результата ,ОПИ проведется на всей 7-ой сетке скважины месторождения X. Выполнить анализ современного состояния применения химических методов ограничения водопритоков и регулирования внутрипластовых перетоков неоднородных коллекторов, обводнившихся за счет различных источников обводнения.

ANNOTATION

The diploma work considered ways to prevent water inflow and with a subsequent increase in the recovery factor during oil production to wells by chemical means, namely, the introduction of a gel-forming reagent based on a silicate-polymer composition (X). It was assumed that a more effective result, pilot testing will be carried out on the entire 7th grid of the well of field X. Analyze the current state of the application of chemical methods for limiting water inflows and regulating in-situ flows of heterogeneous reservoirs that have been watered due to various sources of water cut

Content

INTRODUCTION

In the resource base of the oil industry, the share of hard-to-recover reserves is increasing from year to year. Oil production from reservoirs confined to heterogeneous reservoirs leads to premature breakthrough of injected water through highly permeable zones of the reservoir and, as a consequence, high water cut of the produced wells and low oil production.
In connection with the above, issues related to the justification and development of technologies for in-situ isolation of water inflow in production wells are becoming topical problems. Taking into account the prospects of this direction, the search for new compositions with synergistic properties due to the presence of polymer and silicate characteristics obtained during the synthesis of hydrolyzed polyacrylonitrile with sodium silicate was carried out.

For the first time, a new polymeric reagent based on polyacrylonitrile was synthesized by hydrolysis with sodium silicate to form a copolymer of acrylamide, sodium acrylate and silicic acid imidoester units, capable of forming a strong gel-forming spatial framework when interacting with strong acids.

1. Information about the deposit

Field X is located in the northwestern part of the Buzachi peninsula of the Mangistau region of the Republic of Kazakhstan, and is adjacent to the eastern coast of the Caspian Sea. From this oil field to the nearest city of Akdau) about 210 km. The length of the deposit from east to west is 30 km, width from south to north is 6 km, area is about 180 km2. The surface of this area is a salt and silk threshold, the vehicle is very difficult to pass. Some part is a sand dome and old rocks discovered. The Mangistau region is known for the fact that about a quarter of the recoverable reserves of raw materials are concentrated on its territory. Basically, the fields are due to a complex geological structure, therefore, the exploitation of these fields does not provide an opportunity to extract oil reserves in full volumes, but only 5-7%. Field X is one of 5 large fields, geographically located on the Buzachi peninsula, north of the city of Aktau. The field was discovered in 1974 and development began in 1980. The holders of the license for the extraction of hydrocarbons are company X and the Chinese company X. Field X belongs to shallow (250-500 m) high-viscosity oil fields. Factors such as a complex geological structure, tectonic disturbance, stratigraphic unconformities, lithological variability of rocks led to the need for their thorough geological, geophysical study based on well drilling data, 3D seismic exploration, and the results of hydrodynamic studies during development. development began in 1980. The holders of the license for the extraction of hydrocarbons are company X and the Chinese company X. Field

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The climate in this area is continental, it is significantly influenced by the climate of the Caspian Sea, thereby creating a tangible temperature difference. The air temperature during the day reaches 35-45 ℃ in the summer, in winter the temperature drops to -30 ℃ at night. Despite the fact that the field has been in operation for a long time, it stores colossal oil reserves.

Currently, the field is being developed by Karazhanbasmunai JSC with an office in Aktau. The shareholders of Karazhanbasmunai are CITIC and the Kazakh oil company Exploration Production KazMunayGas, 50% each, respectively. Oil production in 2008 amounted to 2 million tons.

2. Oil and gas content

2.1. Placement of oil and gas deposits

Oil in Field X is a mixture of hydrocarbons of various compositions and weights, which include resins and asphaltenes, the constituent parts of which are sulfur, oxygen and nitrogen. Oil and gas deposits are a product of the accumulation of organic matter together with sedimentary rocks. Oil deposits discovered in the territory of field X are confined to the Lower Cretaceous and Middle Jurassic deposits. Compared to the Kalamkas field, there are fewer Jurassic deposits in the X field. Almost no gas caps have been found and this field X belongs to oil by the nature of saturation. Of the 100% of the explored hydrocarbon reserves of the Buzachi Peninsula, about 23% is accounted for by X. The formation of the productive part of the section is played by the Middle Jurassic and Lower Cretaceous deposits, the boundary between them is determined by interruptions in sedimentation and angular unconformities. The permeability of the Jurassic reservoirs varies from tenths of MD to several D, in turn, the porosity is fixed in the range of 18-40%. Clay nests and interlayers characterize the clay content of the reservoir rocks. Clay matter reduction in pores is no more than 15-20%. There are clay barriers between some productive horizons; in places where there are no clay divisions, the productive horizons are observed to merge. Middle Jurassic oil-bearing complex The Middle Jurassic formations have been drilled through in the submerged sections of the flanks of the structure of field X and at the re-lines at a depth of 389 to 500 m; in the main part of the arch they are eroded. Deposits are represented by intermittent occurrence of sandy-siltstone and clayey rocks. The Middle Jurassic oil complex is composed of deposits of the Aalenian, Bayossian, Bathonian, Callovian stages, the thickness of which reaches 235 m. Lower Cretaceous oil complex Lower Cretaceous deposits are located on the eroded surface of the Jurassic or variegated rocks of the Lower-Middle Triassic with stratigraphic and angular unconformity. The Lower Cretaceous oil-bearing complex is composed of deposits of the Barrias-Valanginian, Lower Hauterivian, Upper Hauteriv-Barremian stages. The deposits are represented by dark gray fine-grained sandstones, greenish-gray mixed-grained siltstones with rare inclusions of variegated clays, dark gray silty clays with sandstone interlayers. Oil of the Buzachinsky arch is characterized by sulphurous (less than 2%), with 18-20% resin content (highly resinous), low pour point, which is -20 ° C. The oil has a high content of trace elements and undersaturation with gas, which is its distinctive feature. Associated gases are mainly 97% methane, the hydrocarbon content is not more than 8%

3 Geological part

3.1 History of the study of the area

In the early 50s of the 20th century on the Buzachi peninsula, gravel aeromagnetic surveys and seismic studies, structural geological surveys using mapping drilling were carried out. In 1960, A.I.Dimakov identified two local uplifts complicating the Sevro-Buzachinsky arch: Zhaman-Orpinsky and X. This situation served as a motive for carrying out parametric and prospecting drilling. From well K-12, drilled in the west of the X structure in 1974, the first oil gusher was received. A huge contribution to the study of the geological structure and oil and gas potential was made by the employees of VNIGRI, RGUNG named after V.I. IM Gubkin, trust "Mangyshlakneftegazrazvedka", "Kazneftegeofizika", which performed significant volumes of field, geological, geophysical, analytical work. The tectonic structure of this region is described in the works of S.N. Alekseichik, then it is covered in more detail in the publications of B.F.Dyakov, A.I.Dimakov, G.V. Shvedov, the geological structure of local uplifts in the center of the Buzachinsky arch is detailed according to the indicators of structural exploration drilling (A.M. Nurmanov, Kh.Zh. Uzbekgaliev and others). The problems of the structural position of the Poleozoic and Triassic complex are interpreted in the works of Vasiliev, Milnichuk, Charygin and others. In the works of Volozh, Votsalevsky, Lipatova, the internal structure of the pre-Jurassic complex of the Buzachi peninsula is investigated. The process of development and formation of the X field directly depends on the features of the paleotectonic structure of the Buzachinsky arch, located at the junction of the East European and Central Eurasian platforms. An extremely detailed description and the first knowledge of the stratigraphy of the productive strata of the Buzachinsky arch deposits are highlighted in the works of V.G. Sukhinin, A.A. Savelyev, further supplemented according to the results of paleontological, palynological studies (S. Teremuratova, L.I.Bykov, etc.). Such production companies as "Mangistaumunaigaz", KazNIGRI, VNIGRI, "Mangistaumunaygeo-fizika" studied the structure of tectonics, stratigraphy, deposits of productive horizons, oil and gas content of the X field. The history of exploration of the Buzachi peninsula is divided into 2 stages. The first knowledge about geology, stratigraphy, tectonics, lithology, oil-bearing capacity of this territory was obtained as a result of geological and geophysical research in the 30s of the XX century by geologists of research and production organizations. The first stage took place in 1941-1959, namely, aeromagnetic, gravimetric surveys and seismic works were organized. Structural-geological survey at a scale of 1: 200000 was carried out using structural mapping drilling in 1956. Thus, geologists compiled the first structural and geological maps. Seismic studies made it possible to clarify and describe the structure of structures. The second stage of the study is associated with the discovery of oil deposits by exploratory well K-12 in the deposits of field X. Oil and gas deposits in the Jurassic-Cretaceous strata were established at the field based on the results of drilling. According to the study of field X and others on the territory of the Buzachi peninsula, the presence of a large Buzachi oil accumulation zone was established. 2.2 Lithological and stratigraphic characteristics The first and complete works on the stratigraphy of the productive strata are described in the works of V.G. Sukhinin, Savelyev in 1976, L.V. Alekseychik supplemented the information with data from palynological and paleontological studies. The collected data of lithological and paleontological studies and stratigraphy were highlighted in the works of V.V. Lipatova and others. Based on the processing of lithological and biostratigraphic results obtained in various research organizations, the study of geological and geophysical materials, the boundaries of the Neocomian and Middle Jurassic productive strata were clarified, in the Permian-Triassic deposits, the allocation of lithological and stratigraphic complexes necessary for understanding the formation and structure of the Jurassic-Cretaceous productive strata. In this area, drilling identified deposits of the Upper Paleozoic, Triassic, Jurassic and Early Cretaceous age (Fig. 2). Below we will consider a description of lithological and stratigraphic complexes. The collected data of lithological and paleontological studies and stratigraphy were highlighted in the works of V.V. Lipatova and others. 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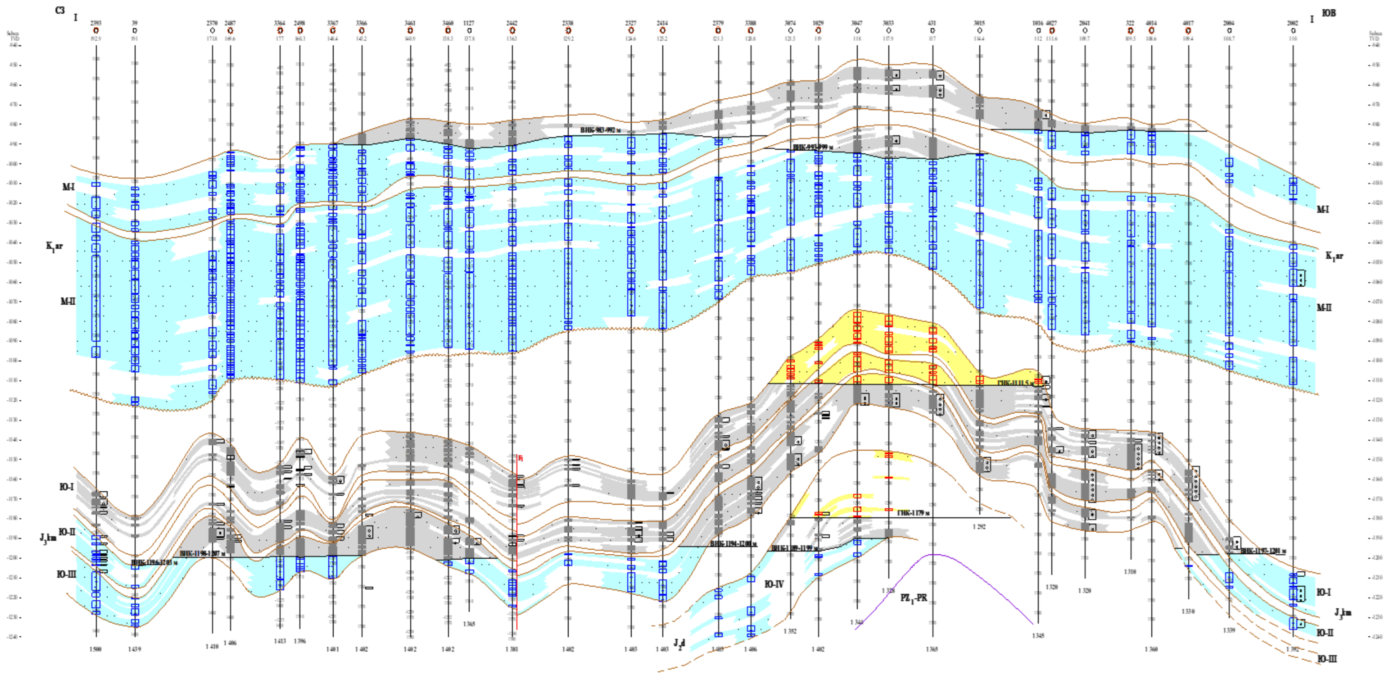
Fig. 2 Lithological-stratigraphic section of field X



3.2 Hydrogeology

The density of the formation water of the X field varies from 1.04 to 1.05, the salinity of the formation water is in the range of 40,000 - 70,000. At the stage of development of the field, the formation water by its properties belongs to calcium chloride, over time the content of minerals gradually decreases. The formation water generally contains 45 mg / l of minerals without hydrogen sulfide, the content of calcium is 1500 mg / l, magnesium - 500 mg / l, chlorine - 27000 mg / l, sulfate - 69 mg / l, bicarbonate - 430 mg / l. All of these figures were obtained in July 1984. In 2001, there is a change in the composition of formation water, which this year showed the total content of minerals by 28000 mg / l, the content of sulfate was 10 mg / l, hydrocarbonate - 525 mg / l, calcium - 1400 mg / l, magnesium - 245 mg / l, chlorine - 16800 mg / l

Deposits of the X Peninsula, including the X field, are hydrodynamically related to a territory with a pronounced elision regime, exhibiting a very complicated water exchange or stagnation of water. Hydrochemically, the formation waters at field X are highly mineralized waters of the calcium chloride type.

4. Main part

The oil and gas industry is one of the most active consumers of technological solutions of modern science. Almost all oil fields and, accordingly, associated petroleum gas

(APG) are currently at the stage of generated reservoir energy and in the reserve depletion mode, which determines the development of new methods of enhanced oil recovery (EOR). Most of the oil fields in the Republic of Tatarstan are at a late stage of development, characterized by a high water cut in oil formations, a progressive decrease in the proportion of oil in the product taken from the well and an increased content of sulfur compounds.

To date, numerous methods of influencing productive formations have been tested at the fields of the Republic of Tatarstan in order to increase their oil recovery and intensify oil production. Provided that waterflooding is applied, the use of chemical reagents is one of the most effective EOR methods. The following basic requirements are imposed on chemical reagents:

- economic expediency;
- environmental Safety;
- indifference to oil.

Silicon dioxide-based chemicals fully meet these requirements.

Currently, materials based on silicon dioxide under the trade name "Silin" have been developed and used for the following processes in the oil industry:

I - water-limiting materials of grades “X1, X2, X3;
II - oil-displacing material –X;
III - material for cleaning hydrocarbons, including APG, from sulfur compounds of the "X" grade.

I Water-limiting materials

Methods using silicon dioxide, namely silicate-containing sodium compounds, are used exclusively for limiting water inflows, isolating highly watered areas of reservoirs and improving the ratio of oil and water mobility in faciesly heterogeneous reservoirs. As a rule, the use of silicates in the Russian Federation is based on in-situ sedimentation, although foreign experience uses silicates as gel-forming systems. It is known that the formation of strong gel-like structures is provided by nanosized particles, this is associated with the manifestation of "quantum-size effects", primarily with a change in the atomic-crystal structure and various physicochemical properties of the dispersed phase. Also important characteristics in the formation of strong gels are the optimal pH value, which corresponds to the range of 2-4 units. pH,

Analysis of literature data, including patent data, showed that the authors, when developing and using technologies using silicate-containing materials, practically do not take into account the structure of silicates and their properties [1].

According to the modern classification, silicate-containing materials are characterized by the molar ratio of the content of silicon dioxide to the oxide of the alkaline cation (silicate modulus - M):, K = 1.0323, the conversion factor to the molar ratio, as well as the degree of polymerization of silica, where L is the number of monomer units. $\boldsymbol{M = \frac{C_{SiO2}}{C_{Na2O}} \cdot K}$

Silicates form the following series of structures [2]:

- highly alkaline systems (ortho-, sodium metasilicates) **M**<2, monomers L = 1;
- liquid soluble glasses M = 2 ÷ 4, these are lower oligomers L = 1 ÷ 25;
- polysilicates M = 4 ÷ 25, higher oligomers L> 25 with molecular weight MM <106;

- sols or colloidal silica M> 25, d> 7 nm, MM> 106.

Water-limiting compositions based on liquid soluble glasses, which have been used in Russia since the 40s and up to the present time, are used both independently and in various compositions. The disadvantages of using these technologies are the relatively low amount of the active principle (SiO2), the difficulty of regulating the properties of the composition providing an effective increase in oil recovery.

Silica sol-based water-limiting systems are not widely used. Although they have a high amount of active principle and ease of adjusting the properties of the composition, their high cost and lack of frost resistance prevent their use in the Russian Federation.

Sodium polysilicates have not previously been produced on an industrial scale. On the basis of the authors' developments, an industrial production of sodium polysilicates was created with the possibility of obtaining polysilicates of the required compositions. These are both aqueous solutions of grade X according to TU 2145-014-13002578-2008, and concentrated crystalline hydrates of sodium polysilicate grade X, readily soluble in water, the use of which significantly reduces transport costs and allows you to obtain technological solutions directly at the wells. The working solution is prepared at the injection site by dissolving the briquettes in water, the process solutions are completely similar to the solutions of product X.

A technology based on polysilicates with the formation of a gel in an acidic medium has been developed. This forms a strong, so-called "ringing" - ringing gel - "ringing", which in highly permeable areas of the formation creates the most effective water barrier.

The structural element of polysilicate is a silicon-oxygen tetrahedron. It is the main constituent of the polymeric form of polysilicates. The difference between polysilicates and other silicate systems is their polymeric form, which is silica particles ranging in size from 4 to 6 nm. The polymer form is 60% or more of the total silica content, which ensures high strength properties of the resulting gel structures.

When considering the comparative economic efficiency of the reagents, testing of technological working solutions of sodium polysilicate was carried out on the UIPK-1M unit to study the permeability of cores, while it was found that the permeability of the fractured reservoir model decreases from 29.76 D at a pressure of 0.2 MPa to 0.0098 D at a pressure of 0.2823 MPa.

As the data analysis showed, the efficiency of sodium polysilicates is 4-5 times higher than the efficiency of liquid glasses due to the use of process solutions with a lower concentration, which provides a low viscosity and allows the use of these solutions in reservoirs with minimal permeability. The optimal ratio of the active principle and cost, frost resistance, make them very attractive.

Since the beginning of the organization of production in 2008 and up to the present, more than 2,700 tons of products have been delivered, of which more than 2,000 tons of reagent X have been supplied to PJSC TATNEFT. Thus, with an average efficiency of 800 tons of additionally produced oil per 1 ton of reagent, 50 % total additional production amounted to more than 1000 thousand tons of oil.

II Enhanced oil recovery

As mentioned above, requirements are imposed on chemical reagents, one of which is economic feasibility. According to this requirement, the most controversial of all EOR is the method based on the use of surfactants (surfactants).

Due to the dependence of the cost of surfactants on the cost of hydrocarbon raw materials, their use depends on the price of oil. Surfactant use methods are the first to stop being implemented when oil prices fall, and they start to be used by the latter when prices rise. Thus, for EOR based on the use of surfactants, it is especially important to increase their technological and economic efficiency [3]. As an example, we can cite the ambiguous results obtained during field tests using surfactant solutions according to the technologies of the Marathon Oil Corporation (Texas, USA), which indicates the complexity and poor controllability of oil displacement processes using surfactants from heterogeneous formations, especially flooded formations.

In Russia, NPO X has developed composite compositions based on nonionic surfactants using oxyethylated alkyl phenols of domestic production. An analysis of the use of individual nonionic surfactants of the OP-10 type to enhance oil recovery of flooded formations showed their low efficiency due to various factors.

Work on experimental and field research of composite systems using surfactants is being carried out at the Institute of Petroleum Chemistry, Russian Academy of Sciences. Compositions based on surfactants are multicomponent, difficult to prepare, expensive, and can cause negative technological side effects.

A system of viscoelastic particles (X) based on silicates has been developed, which belongs to highly dispersed heterogeneous systems, corresponds to the laws of colloidal systems, namely, the presence of two phases: the dispersed phase is a complex of surfactants with silica particles, the dispersion medium is water. The sizes of the dispersed phase are in the range from 5 to 100 nm. Colloidal systems are divided into two classes, lyophilic and lyophobic. System X is a lyophilic system. It is characterized by the presence of a rather extended solvation layer at the interface. System X is capable of spontaneous dispersion. According to the method of production, system X refers to products obtained by the method of chemical condensation.

Application: oil-displacing reagent for intensifying oil production by affecting residual oil saturation, including high-viscosity oils.

Pilot work using the X VUCH reagent was carried out at a field in Western Kazakhstan. In 2010. work began on the injection of reagent X at 8 sections of injection wells.

Oil flow rates in the sections of the reacting (producing) wells ranged from 8 to 30 tons / day, the average water cut in the sections was 75%. The volume of injection of the process solution of reagent X averaged 40 m3, for one well the total volume of injection of the process solution was 80 m3.

The current analysis of the operating modes of the reacting (producing) wells shows several fundamental positive aspects:

- the total daily oil production rate for the past period in 8 areas of treated injection wells increased by 76 tons compared to the baseline indicator (from 178.4 to 254.4 tons / day);

- the total daily flow rate of the produced fluid, against the background of an increase in oil production, decreased by 9 m3, which indicates an obvious positive trend in the process of redistribution of filtration flows in the treated formations;

- there was an increase in injectivity at 5 out of 8 treated injection wells by an average of 48%, which also indicates a redistribution of filtration flows in the treated formations (taking into account the fact of an increase in oil production and a decrease in fluid production). It should also be noted that we are only dealing with the current impact results. As a result of the impact, more than 900 tons of oil have been produced per 1 ton of reagent to date.

In 2015, 5 injection wells were processed

The success rate of treatment was 60%, for 4 months of observation the specific effect of 485 tons of additionally produced oil on well-treatment, the effect continues.

III Development of a method for cleaning associated petroleum gas from sulfur compounds using polysilicates.

The Government Decree of January 8, 2009 No. 7 "On measures to stimulate the reduction of atmospheric air pollution by products of associated petroleum gas flaring" set the task by January 1, 2012 to bring APG utilization to 95%, while the task of utilizing sulphurous APG (30 % of deposits) cannot be solved without effective desulfurization technology.

Existing industrial technologies for chemisorption treatment of associated petroleum gas:

- Sulfurex® process - chemical absorption of hydrogen sulfide and carbon dioxide by caustic alkali NaOH - is implemented by DMT (Netherlands);
- the process of alkali-catalytic purification of associated petroleum gas "SEROKS-GAZ-2" JSC "VNIIUS" (Kazan) is based on the reaction of hydrogen sulfide with alkali with further oxidation on catalysts of sodium sulfide and hydrosulfide to sulfate and thiosulfate. The processes are carried out on apparatus of the absorber type. There are other methods that have not found practical application.

A new, more efficient technology for purifying associated petroleum gas from sulfur compounds using silicate-containing materials has been created.

For this, a colloidal form of modified polysilicate (reagent "X") was developed and synthesized. Analysis of the obtained sample using a D8 X diffractometer from X company showed that this substance has a highly disordered crystal structure, the average crystallite size with an ordered structure is about 100 Å (10 nm). Laboratory tests have shown the high efficiency of the synthesized silicate.

Joint work of NGDU "X" OJSC "X" and LLC "X" at the BPS site carried out pilot work on the APG desulfurization unit with a capacity of 100 m3 / h in the field using APG. Field tests of the associated petroleum gas purification technology have shown the effectiveness of its purification at the unit using the “X” reagent.

The results of the analysis of the composition of the purified associated petroleum gas [14] showed the complete removal of hydrogen sulfide (the concentration of hydrogen sulfide in the initial gas is 43.04 g / m3), a decrease in the concentration of carbon dioxide from 79.79 to 74.71 g / m3

Pilot work on testing various surfactants has been carried out since the seventies, both according to the technology of long-term dosing and injection of weak surfactant solutions, and according to a one-time technology, which consists in pumping low-volume concentrated solutions, micellar surfactants into injection wells. The effect of surfactant solution injection is reflected in a month or earlier, which leads to the advance advancement of the surfactant solution in comparison with ordinary water.

Depending on the geological conditions and surfactant properties, an increase in the recoverable oil reserve per 1 ton of the reagent injected into the reservoir corresponds to 60 - 70 tons.

Evaluation of the efficiency of enhanced oil recovery (EOR) methods shows that the technology of using surfactants (SAS) is one of the most effective EOR. The effect is caused by a decrease in surface tension at the oil-water interface and is used primarily to change the properties of the bottomhole zone of oil reservoirs. However, due to the high adsorption potential of the formations, the effect can be achieved with large volumes of surfactants, which is impractical due to the high cost of reagents. On the basis of the pilot work carried out in the Republic of Tatarstan, no more than 5 out of more than 30 EOR methods using surfactants have been recommended for industrial implementation. Nevertheless, a whole range of technical solutions has been developed, based on the injection of surfactant rims through injection wells.

One of these solutions is the development of methods for using surfactants in the form of viscoelastic particles (VSP). The VUCH system was developed by OOO X.

VUCH is an aqueous dispersion of organic-inorganic compounds, where surfactant molecules are immobilized on the surface of the inorganic phase - silicon dioxide. This makes it possible to significantly reduce the cost of the product while maintaining its effectiveness as an oil-displacing agent. As you know, the limiting value of oil recovery is expressed through the displacement coefficient Kv. At the same time, the oil displacement coefficient of 70-74% is considered to be very high. The use of VUCH, as shown by tests, on core samples reaches 96-98%.

Introduction

The technology for limiting water inflows, isolating highly watered reservoirs and improving the ratio of oil and water mobility in faciesly heterogeneous reservoirs using the “X” reagent is intended for use in oil fields with high and low permeability reservoirs in the section. Increased coverage of reservoirs by waterflooding is achieved through the formation of a water barrier in high permeability reservoirs, enhanced oil recovery by redistributing the flow of injected water by power and displacing oil from low-permeability zones of the reservoir that were not previously covered by the filtration process.

It is obvious that the water barrier formed in highly permeable areas of the formation will be more effective when a strong gel-like structure appears in the formation. It is known that the formation of strong gel-like structures is provided by nanosized particles, this is associated with the manifestation of "quantum-size effects", primarily with a change in the atomic-crystal structure and various physicochemical properties of the dispersed phase. Also important characteristics for the formation of strong gel-like structures are the optimal pH value, which corresponds to the range of 3-4 units. pH, silicon dioxide (SiO2) concentration and temperature.

Gelation occurs in the formation as a result of polysilicate polymerization

"X" when interacting with acid. Depending on the concentration of the acid and the amount of stabilizer, the process takes place within a predetermined time, which is determined depending on the characteristics of the formation. The formation of water-insulating screens based on the "X" reagent directly in reservoir conditions allows creating zones with increased filtration resistance and eliminating water breakthrough through highly permeable interlayers to the bottom of production wells.

The gelation time of the system is also technologically important, which must ensure the injection of the necessary volumes of solutions to ensure the specified value of the insulating screen and prevent in any case the formation of gel, both in the equipment used, and in the tubing and in the bottomhole zone.

The developed technology based on "X" grade polysilicates allows the formation of strong gels in an acidic medium, the so-called
"Ringing" - ringing - "ringing" gels. Similar technologies using liquid glass lead to the predominant formation of coagulation structures, since the transfer from the acidic region occurs with an increase in the concentration of salts.

Gel-forming systems based on sodium polysilicates "X" with adjustable gelation time allow creating screens of any thickness at a given distance from the bottomhole zone with the formation of gels with the required strength, resistance to erosion and depression in the highly permeable formation zone, which makes it possible to use them for injection wells. The technology of using polysilicates provides for differential-integral injection of the reagent (changes in the density and flow rate of the reagent depending on the injectivity and injection pressure).

Application of the technology makes it possible to align the injectivity profile, block washed zones and cracks, eliminate the escape of injected water into mixed formations due to a given screen size, limit the injectivity of wells and subsequent redistribution of the displacement front to low-permeability productive layers that were not previously exposed to impact.

1 Work program

Based on contract No. 13-КGД1-0338 dated May 29, 2013. to conduct pilot tests (EPT) of technology for limiting water inflows, isolating high-watered formations and improving the ratio of oil and water mobility in facies-inhomogeneous reservoirs, the technology was tested using reagent "X" in the conditions of field "X" JSC "X"

For pilot testing, a section of injection well No. 479 was selected and the reacting production wells No. No. 485, 486, 480, 469, 1807, 1809, 487, 470, 1757, 455, 467, operating layers of horizons D, D, were analyzed as production wells. selected - №№ 485, 486, 480, 469, 470, 1757, 467, Wells layout is shown in fig. one.

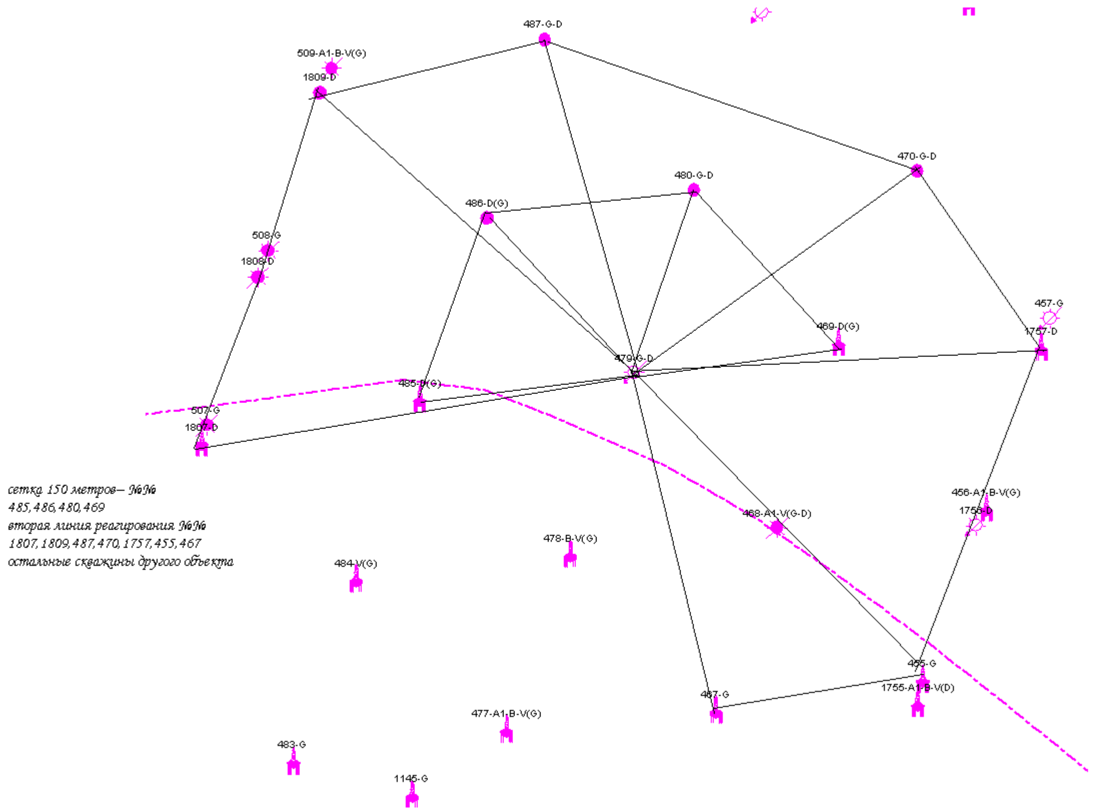


Fig. 1 Scheme of the location of wells at the pilot site

Work on the technology using reagent "X" was carried out at injection well No. 479 of field X with the participation of representatives of the customer JSC "X" with the participation of specialists from JV NPO X LLP, X LLC and X LLC.

The well preparation was carried out by the customer, the supply of reagent "X" and the injection of the process solution into the well by the contractor JV NPO "X" LLP in accordance with the approved technological work plan agreed with JSC "X".

Reagent X used in the technology is supplied in two grades:

- an aqueous solution of high-modulus sodium polysilicate grade X;

- crystalline hydrate of high-modulus sodium polysilicates grade X, is a more concentrated form of product grade X, differs in its state of aggregation (briquette).

The product of the “X” brand is delivered in steel drums with a capacity of 200 dm3, of the “X” brand in polypropylene bags with a capacity of 40 dm3 with a polyethylene liner.

Reagent "X", approved for use in the oil industry - certificate of conformity No. TEK RU.HP25.N03811, certificate for the use of a chemical product in technological processes of oil production and transportation No. 153.39.RU.245860.04212.10.11 dated 12.10.2011.

The technological process was carried out using standard technological equipment and a mixing device supplied by the contractor.

Perforation interval along the well according to the customer's request 305.0-322.0 and 333.8- 340.5 m, penetrated thickness h = 23.7 m, actual interpretation interval according to [1] 312.4-319.6 and 336, 6-340.5, thickness, respectively, 11.4 m.

2 Brief geological and physical characteristics of the experimental site

Reservoirs of formations G, D are represented by clayey silty and sandy rocks, to which oil deposits are confined.

The oil-saturated thickness of the G formation ranges from 8.8 to 16.9 m. The average value of the porosity in the formation is 0.319 unit fraction, the permeability is from 21 to 8191 μm2.

For reservoir D, the oil-saturated thickness ranges from 3.8 to 6.4 m.

The weighted average value of porosity is 0.311 unit fractions; permeability - from 21 to 3394 μm2.

For the aggregate of objects, the density of oil in reservoir conditions is 0.93 kg / dm3, viscosity is 449 mPa · s, the average value of the saturation pressure is 2.03 MPa, and the average value of gas content is 7.07 m3 / t.

The physical properties and chemical composition of the formation waters of the X field are presented in Table 1, the water belongs to the calcium-chlorine type, slightly mineralized.

Table 1

Physical properties and chemical composition of formation waters of field X

Naimenovanie	pH, p units H	R, g / cm3	Ca	Mg	Na + K	HCO3	SO4	Cl	∑ min-tion, mg / l	Water type
			mg / l							
Plast. water (Wed.no.)	7.0	1.033	1370	602	15043.2	252.1	203.6	26862.13	44493.9	Cl-Ca

3 Geological and technical characteristics of the experimental wells of the centers of influence on the formation with reagent X.

Well center No. 479

Injection well No. 479. Production string 168.3 mm. Artificial bottom hole 345 m. It has been operating as mining since 1984, as of June 30, 2013. the daily oil production rate was 0.89 tons, the water cut was 97.47%, after the transfer of the well to the injection category, the injectivity in the G reservoir was 42.78 t / day, in the D reservoir - 16.86 t / day. at an injection pressure of 5.7 MPa.

As of June 30, 2013. injection well No. 479 had an injectivity of 42.3 m3 / day; stratum D - 21.7 m3 / day, stratum D - 20.6 m3 / day. at a wellhead pressure of 4.3 MPa.

Production wells of the hearth.

Well No. 485... It was put into operation on 09.04.1984 in the D 306 - 325, (G) reservoir.

At the beginning of pilot production, 28251 tons of oil, 231730 tons of water were produced; worked for 8302 days.

The well was operating at an average fluid rate for the last 4 months of 16.97 m3 / day, with an oil rate of 0.26 t / day. with a water cut of 98.4%.

Well No. 486... It was put into operation on 16.04.1984 for layers D 329 - 336 m, G 299 - 320 m. At the beginning of pilot production, 26204 tons of oil, 588,052 tons of water were produced; worked 8014 days.

The well worked with an average fluid rate for the last 8 months of 175.91 m3 / day, with an oil rate of 2.1 t / day. with a water cut of 98.8%.

Well No. 480... It was put into operation on 30.04.1984 in formations D, G. At the beginning of pilot testing, 34618 tons of oil, 364079 tons of water were produced; 9374 days worked.

The well worked with an average fluid rate for the last 8 months of 93.34 m3 / day, with an oil rate of 1.46 tons / day. with a water cut of 98.4%.

Well No. 469... It was put into operation on 20.06.1984 for layers: D perforation interval 335 - 341 m, for layer G - 303 - 323 m.

At the beginning of pilot production, 16608 tons of oil, 242118 tons of water were produced; worked 6899 days. The well was operating at an average fluid rate over the last 8 months 12.33 m3 / day, with an oil flow rate of 0.05 tons / day. with a water cut of 99.63%.

Well No. 470... It was put into operation on 31.08.1984 for layers D, G.

At the beginning of pilot production, 30344 tons of oil, 293409 tons of water were produced; worked for 8992 days. The well was operating at an average fluid rate over the last 8 months 22.43 m3 / day, with an oil flow rate of 0.33 tons / day. with a water cut of 98.49%.

Well No. 1757... Commissioned on 31.08.1987 for seam D 330 - 336 m. Transferred from injection to production from 30.11.2012. At the beginning of pilot production, 735 tons of oil, 10658 tons of water were produced; worked for 286 days.

The well was operating with an average fluid rate for the last 8 months of 40.02 m3 / day, with an oil rate of 2.54 tons / day. with a water cut of 93.22%.

Well No. 467... Commissioned on 31.09.1984 in reservoir G. At the beginning of pilot production 19344 tons of oil, 114124 tons of water were produced; worked 6565 days.

The well was operating at an average fluid rate for the last 8 months of 51.02 m3 / day, with an oil rate of 1.69 t / day. with a water cut of 96.57%.

Geological information on production wells is presented in Table 2.

Table 2.

Geological information on production wells

Well number s	Roof, m	Sole, m	Horizon	Total thickness, m	Effective. thickness, m	Total effective. neftenas. thickness, m	Clay content, fractions of a unit	Porosity, fractions of a unit	Insight, mD	Saturation		Ud. electr. resistance, ohm	Lithologicalcharacteristic	Saturation
										Kv, share units	Kng, share units			
470	296.9	297.8	G	0.8		26.9	0.37	0.31	56	0.62	0.38	2.7	clayey aleurolite	Water
	298.8	299.7		0.9			0.40	0.31	34	0.63	0.37	2.7	clayey aleurolite	Water
	300.0	300.6		0.6	0.6		0.40	0.31	36	0.55	0.45	3.5	clayey aleurolite	Oil
	300.8	301.9		1.1	1.1		0.39	0.31	43	0.54	0.46	3.7	clayey aleurolite	Oil
	302.6	312.9		10.3	10.3		0.14	0.36	884	0.26	0.74	13.0	clayey sandstone	Oil

	316.0	316.6		0.6	0.6		0.37	0.31	52	0.50	0.50	4.2	clayey aleurolite	Oil
	326.8	332.4	D	5.6	5.6	11.3	0.15	0.36	766	0.28	0.72	12.6	clayey sandstone	Oil
486	300.1	300.6	G	0.5	0.5	31.4	0.37	0.31	57	0.55	0.45	3.4	clayey aleurolite	Oil
	301.7	308.8		7.1	7.1		0.13	0.36	950	0.35	0.65	7.2	clayey sandstone	Oil
	309.0	316.9		7.9	7.9		0.16	0.36	648	0.30	0.70	10.0	clayey sandstone	Oil
	318.9	319.4		0.5			0.32	0.32	101	0.59	0.41	3.0	aleurolite	Water
	329.5	335.9	D	6.4	6.4	12.8	0.19	0.35	514	0.33	0.67	9.1	clayey sandstone	Oil
487	297.5	298.4	G	0.8		14.7	0.40	0.31	37	0.65	0.35	2.5	clayey aleurolite	Water
	304.5	310.0		5.5	5.5		0.17	0.35	618	0.28	0.72	11.3	clayey sandstone	Oil
	311.9	313.3		1.4	1.4		0.14	0.36	874	0.23	0.77	16.5	clayey sandstone	Oil

	325.9	329.7	D	3.8	3.8	7.6	0.03	0.38	2553	0.26	0.74	12.5	sandstone	Oil

4 Pilot testing

4.1 Technical support

The work was carried out using the following special equipment:

1) cementing unit (type ЦА-320) - 2 pcs .;
2) tank truck AC;
3) blending chute tank - 2 pcs .;
4) mixing device UMP;
5) Eurocubes for the preparation of the technological solution.
6) acid was supplied in eurocubes;
7) Eurocubes for the preparation of the technological solution.

4.2 Technological process for the preparation of solutions based on the reagent "Silin"

The technology of application consists in injecting working solutions of a composition prepared from polysilicate grades "X" and "X1", inhibited hydrochloric acid and a stabilizer, followed by injection with standard equipment into an injection or production well, then formation occurs in the formation after a specified time (from 10 to 72 hours) of strong acidic gels, stable at temperatures up to + 250 ° C. The technological solution is prepared by dilution with fresh water (density less than 1.05 kg / dm3) 4 - 10 times from commercial forms of brands "X" or "X1", which depends on the geological field conditions.

The technological process of injection of reagent "X" was carried out in accordance with the developed technological plan and instructions for the technological process. The injection of the process solution of the reagent "X" under normal operating conditions into the well was carried out at a pressure and flow rate not higher than the injection of water from the pump station.

4.2.1 Technological operations of the process

4.2.1.1 The injectivity of the well was determined with 8 m3 of technical water.

4.2.1.2 A working solution "X" of a given concentration (6-10%) was prepared. For this purpose, polysilicate "X" was poured into a container with a mobile stirring device from a transport container through a durit sleeve with a quick-release connection, then the required amount of fresh water was added. The stirring device was turned on for 1-2 minutes.

A working solution of hydrochloric acid inhibited 3% concentration was prepared. For this, 800 dm3 was mixed in a container with a stirring device.

fresh water and 100 dm3 hydrochloric acid. The stirring device was turned on for 1-2 minutes.

4.2.1.3 Preparation of technological solution "X". For this purpose, the required volume of the working solution of 3% hydrochloric acid was poured into a container with a stirring device from a container with a working solution of inhibited hydrochloric acid through a durite sleeve, and a stabilizer was added in an amount of 0.1 dm3. The stirring device was turned on. From the container with the working solution "X" was added the calculated amount of the working solution "X". The reagents were added according to the labels on the cube container. The process solution had a pale pink color; preparation of the process solution is not allowed

The "X" is orange or yellow. After filling the capacity of the unit, the process solution was injected, while its preparation in the eurocube continued in the above way.

4.1.2.1.5 The process solution X was injected in the amount of 113 m3.
Estimated target gel time was 12 hours

4.1.2.1.6 At the end of the work, the reagent was pumped into the reservoir with a volume of fresh water, and the final injectivity was determined.

Scheme.1 Technological scheme of injection of the reagent "X"

DISPLACEMENT FLUID

B UFF E R

TECHNOLOGICAL SOLUTION

"X"

B U FF E R

On August 28 - 31, preparatory work was carried out. Made the preparation of the solution "X" from the concentrate "X". The well was treated on September 1-2, 2013. At the start of the work, the injection pressure was 0 MPa. In the process of injecting the process solution, the injection pressure rose to 1 MPa, after the temporary shutdown of the reacting production wells (No. 485, 486, 480) - up to 2 MPa.

After treatment with the process solution of reagent "X", the well injectivity was 45 m3 / day at an injection pressure of 2 MPa.

The sequence of the technology implementation is reduced to the injection of fresh water before the rim, preparation of a gel-forming composition of a certain composition and volume immediately before injection into the formation and its injection into the formation, followed by pumping with fresh water and the necessary exposure for gelation.

During the injection, the following technological parameters were monitored:

- injection pressure according to the pressure gauge;

- the concentration of the reagent X is calculated based on the passport data for the product.

Reagent consumption per well 479 amounted to 27 tons or 1.14 tons per meter of reservoir thickness.

The total volume of the process solution was 113 m3.

After the treatment, it is recommended to reduce the fluid production at the reacting production wells to the recommended fluid flow rate of 30-40 m3 / day.

To assess the technology's ability to redistribute filtration flows and injectivity profile, it is necessary to conduct well logging (T °) and hydrodynamic studies for treated wells.

5 Analysis of processing results

Evaluation of the technological efficiency of treatment of injection well 479 was carried out according to the dynamics of the indicators of production wells: average daily oil and liquid flow rates provided by the customer, as well as the value of water cut in the produced products in percent as of January 31, 2014.

The dynamics of the main indicators of injection well No. 479 and reacting production wells is shown in Fig. 2. The operating schedules of the reacting wells are shown in Fig. 3-9.

The analysis of the pilot test results was carried out based on the results of the production wells

No. 485, 486, 480, 469, 470, 1757, 467.

After exposure to reagent "X", there is a decrease in fluid production from 372 to 265 (average value 212) m3 / day, as well as a decrease in water cut from 98% to 95.6%. Changes in fluid production and water cut allow one to judge the positive reaction of the producing wells when exposed to the proposed technology with further monitoring of the operating mode of the producing wells, since the reagent action time is from a year to one and a half years.

At the center of well No. 479, we have two wells No. 469, 470,48,467, 1757 with technological effect on oil and two wells No. 486, 480 with technological effect on the rate of reduction of produced water. To a greater extent, the effect of treatment was reflected in the operating modes of production wells No. 469, 467. In my opinion, the result of the impact mostly affected horizon D.

In general, according to the results of observation for 5 months, the following was established for the focus of influence: a decrease in the produced water by an average of 43%, an increase in the rate of oil production by 12.8%. Since the beginning of implementation (5 months), additional oil production has been obtained in the amount of about 416 tons. The calculation results are presented in Table 3. Calculation of the indicator (WPT), calculated by the formula: Keff (WPE) = Qn / (qn), is also presented in Table 3.

Summing up, we can state the fact of the formation of new filtration flows in the formations, and, in general, an increase in the coverage of injection.

With a further increase in the pressure gradient, the gel begins to break down, and the permeability increases accordingly., but the initial permeability of the porous medium is not achieved even at pressure gradients of the order of 8-10 MPa / m.

In water-saturated horizons, the gel is distributed throughout the entire thickness of the formation, which leads to a more significant decrease in their permeability than in oil-saturated horizons, where the distribution and formation of gel occurs only in the zones washed with water.

The degree of decrease in the permeability of the porous medium depends on the strength of the gel and the volume of the injected solution.

When using polysilicate gels to level the injectivity profile in reservoirs of heterogeneous permeability, the injection of the reagent should be carried out at the stage of high oil saturation of the low-permeability part of the reservoir and a sufficiently high production of high-permeability. The porous medium occupied by the gel has some water permeability. In the event of a breakdown of the gel in a porous medium, it begins to filter through the largest pores, reducing the permeability of the reservoir in some cases until the complete cessation of filtration.

The value of the specific technological effect of the pilot tests was 416 tons of additionally produced oil, a decrease in the production of associated water by more than 26 thousand tons per 1 well treatment with an effect duration of 5 months (observation period)

Table 3.

Dynamics of changes in indicators of development of stimulation of the reservoir with the reagent "Silin VN-M"

roomwell	date	Liquid flow rate, t / day	Oil flow rate, t / day	Water flow rate, t / day	Water cut,%	Number of days	Number of add. oil, t	Decrease in water, t	K eff
one	2	3	four	five	6	7	eight	nine	10
469	Before processing	12.33	0.05	12.28	0.996	16.13			
	30.09.2013	12.15	0.04	12.11	0.997	27			
	31.10.2013	12.83	0.09	12.74	0.995	31			
	30.11.2013	15.50	0.15	15.35		thirty	15,427		**2,257**
	12/31/2013	16.03	0.15	15.88		31			
	01/31/2014	19.90	0.31	19.59		31			
	After processing	15.28	0.15	15.13	0.996	150			
470	Before processing	22.43	0.33	22.10	0.98	30.34			

	30.09.2013	16.78	0.31	16.47	0.988	27			
	31.10.2013	16.73	0.41	16.32	0.985	31			
	30.11.2013	17.83	0.46	31.86		thirty	27,713		**0.557**
	12/31/2013	32.68	0.82	30.96		31			
	01/31/2014	31.55	0.59	30.96		31			
	After processing	23.11	0.52	16.40	0.99	150			
480	Before processing	93.34	1.46	91.88	0.98	30.25			
	30.09.2013	45.93	1.11	44.82	0.986	27			
	31.10.2013	45.03	1.00	66.84	0.986	31			
	30.11.2013	43.13	0.88			thirty	-38.306	6727.86	**-0.256**
	12/31/2013	53.55	1.44			31			
	01/31/2014	54.06	1.00			31			
	After processing	48.34	1.09	55.83	0.99	150			

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Continuation of table 3.

one	2	3	four	five	6	7	eight	nine	10
485	Before processing	16.97	0.26	16.71	0.98	12.00			
	30.09.2013	12.63	0.20	12.43	0.990	27			
	31.10.2013	12.45	0.27	12.18	0.986	31			
	30.11.2013	12.40	0.34	12.06		thirty	18,607	361.01	**0.476**
	12/31/2013	18.26	0.54	17.72		31			
	01/31/2014	17.68	0.58	17.10		31			
	Wed value	14.68	0.39	14.30	0.99	150			
486	Before processing	175.91	2.10	173.81	0.99	30.12			
	30.09.2013	55.83	0.73	55.10	0.993	eighteen			
	31.10.2013	23.21	0.25	22.96	0.993	fourteen			
	30.11.2013	39.13	0.44	38.69		thirty	-178.36	15681.6	**-0.687**
	12/31/2013	59.26	0.74	58.52		31			
	01/31/2014	60.03	1.1	58.90		31			

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			3						
	Wed value	47.49	0.66	46.83	0.99	124			
467	Before processing	51.02	1.69	49.33		30.37			
	30.09.2013	38,00	2.25	35.75		thirty			
	31.10.2013	40.29	1.86	38.43		31			
	30.11.2013	40.67	3.06	37.61		thirty	157.04	2015.25	**0.615**
	12/31/2013	37.38	3.06	34.32		29			
	01/31/2014	37.23	3.42	33.81		31			
	Wed value	38.71	2.73	35.98		151			
1757	Before processing	40.02	2.54	37.48	0.93	30.12			
	30.09.2013	31.29	3.54	27.75	0.921	27			
	31.10.2013	33.16	4.28	28.88	0.912	31			
	30.11.2013	32,60	5.05	27.55		thirty	197,686	1269.47	**0.562**
	12/31/2013	37.20	3.76	33.44		24			
	01/31/2014	29.93	3.21	26.72		27			

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Wed value	32.84	3.9 7	28.32	0.92	139		
Total						416,4 75	26055.2

thi

Conclusion

it is advisable to carry out it for 5-10 years. Enhanced oil recovery using gelling systems is an effective way to extend the life of oil fields, which does not require complex equipment and significant costs. The efficiency criteria are taken as a decrease in the volume of produced water, a decrease in the water cut of the produced products, and additional oil production. The criteria for the effectiveness of exposure to reagent "X" are generally met. I would like to note that the efficiency of the work performed could be higher if the volumes of the injected process fluid were close to optimal.

In general, for the analyzed area, additional oil production due to a decrease in water cut by 416.5 tons. The use of the technology made it possible, during pilot testing, to state the fact of a significant reduction in the withdrawal of associated produced formation water, which amounted to 26055 tons for the analyzed period and, accordingly, to reduce the cost of oil production. With highly permeable and water-saturated sandstones, the optimal specific flow rate of the solution is 20 m3 per 1 meter of the reservoir thickness, in fact, 103 m3 was injected, which corresponds to 4.34 m3 / m. Reagent consumption amounted to 27.48 tons, respectively, 1.16 tons of reagent per 1 m of reservoir thickness.

Economic indicators of optimization options

Initial data for calculating the economic effect of conducting pilot testing

Indicators	Unit rev.	Comparison base	New technology
Oil production	thousand tons	1843.2	1851.2
Additional production due to the event	thousand tons		eight
Cost of production of 1 ton of oil.	tg / t	978	
Including conditionally variable costs	tg. T	470	
Event costs	t. tg.		1948
Wholesale oil price	tg.	990	990

The cost estimate of costs includes operating costs for the production of additional oil and the costs of carrying out activities, determined by the formula:

DЗт = DЗ + З /

where D3 - operating costs for the production of additional oil, tg .;

3 / - costs of holding the event, tg.

DZt = 2256.0 + 389.6 = 2645.6 t. Tg.

The amount of additional operating costs is determined by the product of the sum of the conditionally variable items in the calculation of the cost of one ton of oil by the additional annual volume of oil production.

Provisional variables include those costing items, the costs of which directly depend on the amount of oil produced. These articles are:

1) The cost of energy used to extract oil.

2) Expenses for artificial stimulation of the reservoir.

7) Expenses for the collection and transportation of oil.

8) Expenses for technological preparation of oil.

10) Expenses for the maintenance and operation of equipment.

Each of the above articles is complex, i.e. consists of several cost elements, some of which do not change with production growth. Therefore, when calculating additional costs, a coefficient of - 0.6 is used and the amount of additional costs is calculated by the formula:

D3 = (No. 1 + No. 2 + No. 7 + No. 8 + No. 10) * DQ * 0.6 tg.

where (No. 1 + No. 2 + No. 7 + No. 8 + No. 10) is the sum of conditionally variable items in the calculation of the cost of 1 ton of oil before the implementation of the measure, tg .;

DQ - additional oil production, t;

0.6 is a coefficient taking into account that each of the listed items does not increase in direct proportion to the increased annual oil production.

D3 = 470 * 8000 * 0.6 = 2 256 000 tenge.

The cost estimate of the cost of oil production without using the measure is calculated by the formula:

Зт1 = Qo * Co, тг.

where Qo is the volume of oil produced before the event, t;

Co - prime cost of 1 ton of oil produced before the event, rubles.

Зт1 = 1843.2 * 978 = 1802649.6 tg.

The cost estimate of the cost of oil production using the measure is calculated using the formula:

Зт2 = Зт1 + D3

Зт2 = 1802649.6 + 2645.6 = 1805295.2 tons.

Hence, the production cost of 1 ton of oil produced using the measure will be:

Ct = Зт2 / Qt, tg./t

Ct = 1805295.2 / 1851.2 = 975.2 tenge.

When assessing the economic efficiency of the application of technological processes that ensure an increase in oil production, the economic effect is the profit remaining at the disposal of the enterprise. The increase in the balance sheet profit from additional oil production is calculated using the formula:

DP = (Ct-Ct) * Qt - (Ct-Co) * Qo, m.

DP = (990 - 975.2) * 1851.2 - (990 - 978) * 1843.2 = 5279.36 tons.

Income tax is calculated using the formula:

H = DP * 24/100, tg.
where 24% is the income tax rate.

H = 5631.09 * 24/100 = 1351.46 t. Tg.

The profit remaining at the disposal of the enterprise is calculated by the formula:

P = DP-N, tg.

P = 5279.36 - 1267.05 = 4012.31 t. Tg.

Further, a comparative table of technical and economic indicators is compiled.

Table 7 - Comparative table of technical and economic indicators

Indicators	One. rev.	Comparison base	New technology	Deviations (+/–)
Annual oil production	thousand tons	1843.2	1851.2	+8
Event costs	tg.		389.6	
Cost of 1 ton of oil	thousand tenge	978	975.2	-2.8
Increase in balance sheet profit	thousand tenge		5279.36	
Income tax	thousand tenge		1267.05	
Profit remaining at the disposal of the enterprise	thousand tenge		4012.31	

As can be seen from the table, after the pilot testing and the introduction of the reagent, it shows that the completed project is considered cost-effective, with the lowest operating costs.

8 Protection of subsoil and natural environment

Environmental monitoring for the protection of subsoil and the environment at field X of NGDU "X" is carried out on the basis of the following documents:

- Environmental Code of the Republic of Kazakhstan No. 212-III dated 09.01.2007. [2];

- Order of the Minister of Environmental Protection of the Republic of Kazakhstan No. 204-p of June 28, 2007 "Instructions for assessing the impact of planned economic and other activities on the environment during the development of preplanned, planned, pre-design and project documentation" [10].

9 Protection of atmospheric air from pollution

The purpose of atmospheric air monitoring is to obtain information on the emission of pollutants, on possible changes in exposure field X on the quality of the air and includes technical, technological and organized environmental measures, strict implementation of which will lead to minimization of the impact of the planned activity on the environment.

Measures taken for field X to reduce the harmful effects of the oil production facility are sufficient, according to the calculated indicators of air pollution during normal operation, as they provide sanitary requirements for air quality.

10 Protection of surface and ground waters from pollution and depletion

The region's water resources are limited and represented by surface and ground waters.

Monitoring of water bodies is a part of the environmental monitoring system, which includes:

- regular monitoring of the state of water bodies, quantitative and qualitative indicators of waste and groundwater;

- assessment and forecasting of changes in the state of water bodies, quality indicators of groundwater.

The analysis of the conducted environmental monitoring of groundwater showed that the excess of the maximum permissible discharges (MPD) by field X was not observed.

11 Radiation situation

It is well known that natural organic compounds, including oil and gas, are natural active sorbents of radioactive elements. Their accumulation in oil, gas condensate, formation waters is a natural geochemical process.

Radiation safety is ensured in accordance with the Law of the Republic of Kazakhstan dated April 23, 1998 No. 219-1 "On radiation safety of the population" [12].

The results of radiation monitoring of operating oil wells of the X field indicate the radiation homogeneity of the investigated structures of oil and gas facilities, as well as the territory where these facilities are located. No radioactive anomalies caused by natural or man-made radioactive contamination were found.

Conclusions:

The results of monitoring studies have shown that field X does not have a significant negative impact on the environment, provided that all environmental protection measures are observed.

12 Occupational health, safety and fire prevention measures

In accordance with the Decree of the Government of the Republic of Kazakhstan No. 14 of January 16, 2009 "General requirements for fire safety" [7], this production is classified as category "A", and the sanitary characteristics - to category "G". In terms of explosiveness, the main technological areas of production are classified as "V-1G" and "V-1a" according to the PUE RK [11].

The main dangerous sources of adverse effects on the human body are equipment and apparatus containing oil, gas, oil products in any quality, i.e. almost the entire technological process is associated with the likelihood of adverse effects on humans.

High pressures in pipelines, operation of equipment using open fire (for example, heating furnaces), evaporation of gases and oil, the use of sophisticated technological equipment with rotating mechanisms, etc. necessitates work with strict observance of safety and industrial sanitation rules.

For all personnel, it is necessary to periodically conduct briefings and trainings on safety measures and pass exams on safety measures, as well as a constant reminder to all operating personnel of the need to comply with safety rules.

The temperature of the outer surfaces of equipment and casings of heat-insulating coatings should not exceed the autoignition temperature of the most explosive and fire hazardous product, and in places accessible to service personnel, it should not exceed 45°Indoor and 60°C for outdoor installations.

The movable parts of the equipment are made in a closed design with protective devices.

Technological installations are equipped with fire-fighting systems, foam, gas and water in accordance with VNTP3-85 and fire-fighting automation in accordance with SNiP RK 2.02-15-2003 [18], incl. foreign production. In each shift, a fire safety officer must be appointed. Premises, structures and workplaces are provided with daylight and electric lighting in accordance with SN RK 2.04-02-2011 "Natural and artificial lighting" [17].

Due attention must be paid to the registration documentation, which contains information about all technological processes.

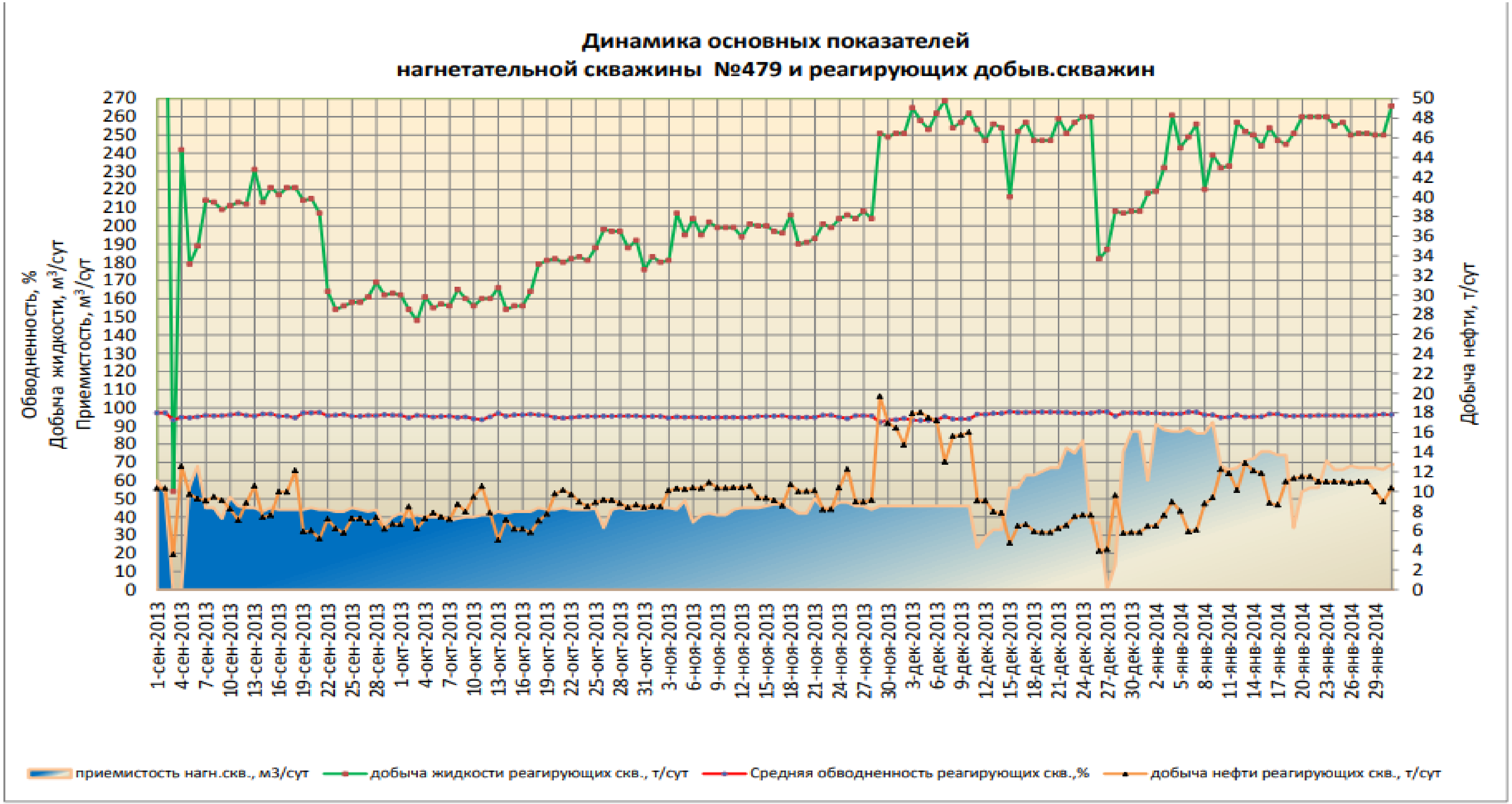
One of these documents is the "Log book for recording drilling fluid when drilling wells." This log records the drilling mud density for four hours.

In addition to the technologically necessary logs themselves, it is imperative to keep a "Safety Check Log" at the sites (objects) of the enterprise.

The enterprise must develop and approve in the appropriate order a "Plan for the elimination of possible accidents", which, taking into account specific conditions, must provide for prompt actions of personnel to prevent accidents and liquidate emergencies.

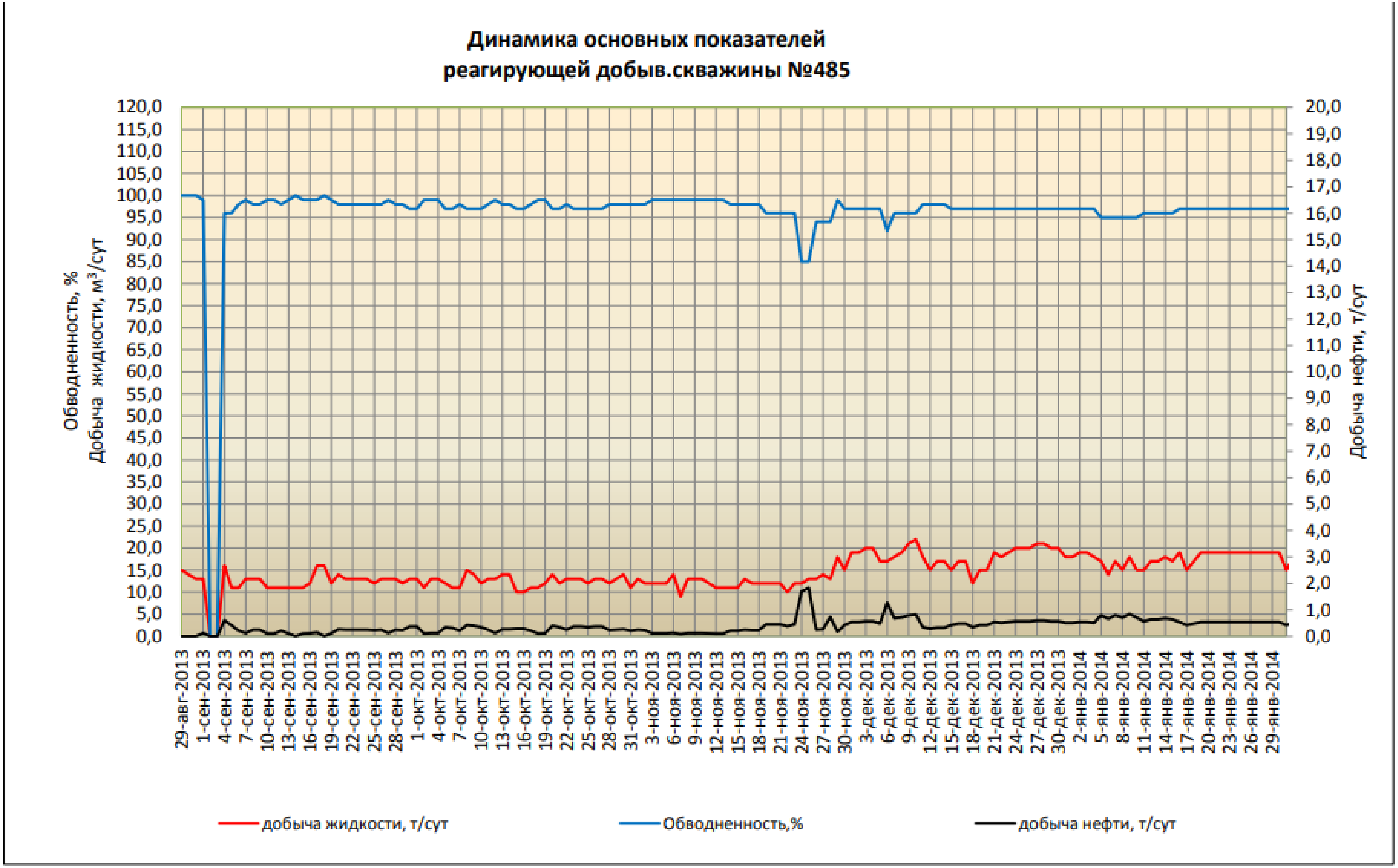
Before starting work, persons recruited must undergo preliminary training organized by the employer, followed by mandatory testing of knowledge on occupational safety and health. Employees who have not undergone preliminary training, instruction and testing of knowledge on occupational safety and health are not allowed to work. The enterprise must provide the employee at its own expense with overalls, special footwear and personal protective equipment against the effects of harmful and (or) hazardous production factors in the prescribed time frame to wear them and monitor the use of individual and collective protective equipment, overalls for the intended purpose.

For the prevention and the actual safe conduct of work, introductory, current and extraordinary briefing of the working personnel is of paramount importance.



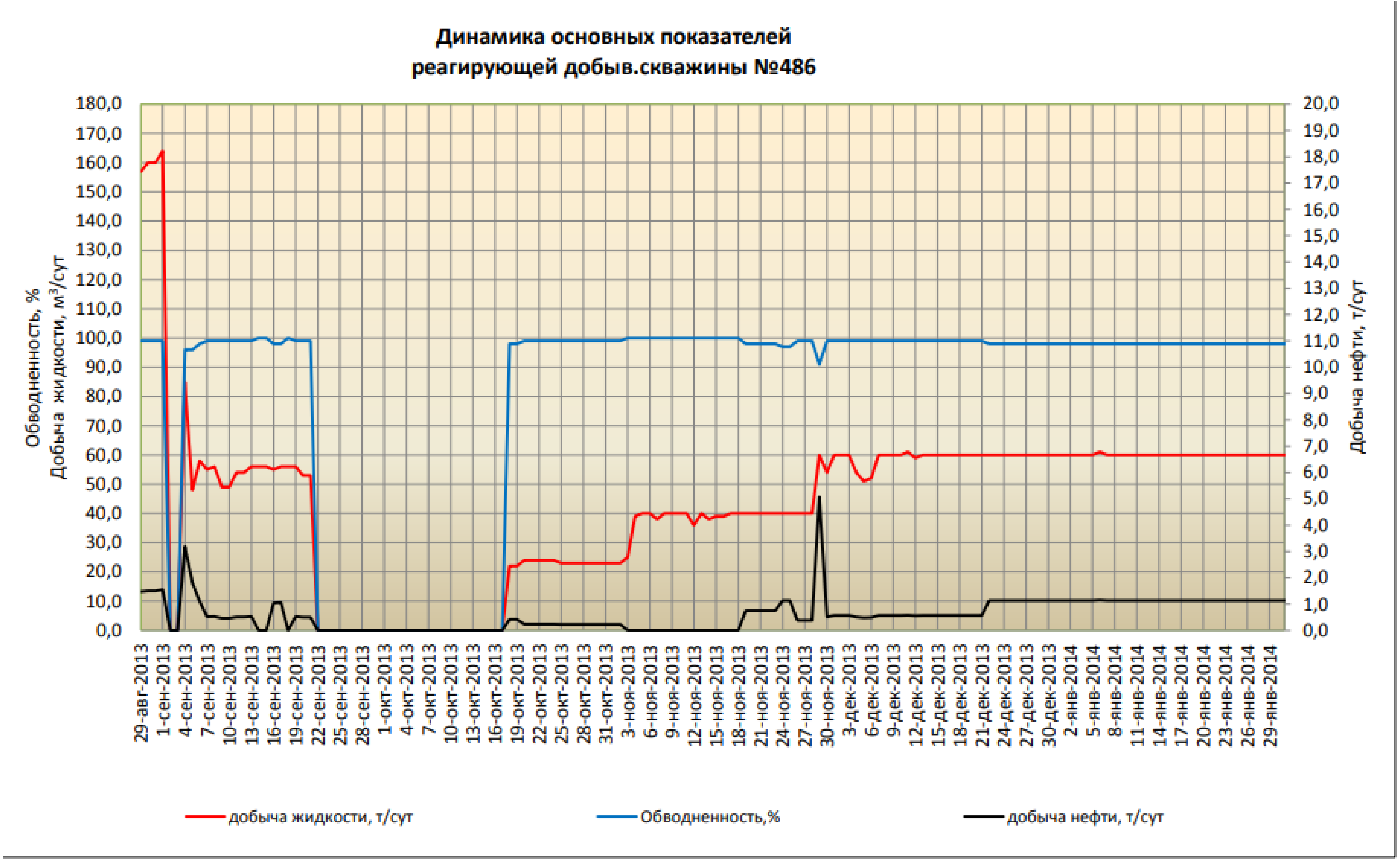
Динамика основных показателей
нагнетательной скважины №479 и реагирующих добыв.скважин
Обводненность, %
Добыча жидкости, м3/сут
Приемистость, м3/сут
Добыча нефти, т/сут
приемистость нагн.скв., м3/сут
добыча жидкости реагирующих скв., т/сут
Средняя обводненность реагирующих скв.,%
добыча нефти реагирующих скв., т/сут

Рис. 2



Динамика основных показателей
реагирующей добыв.скважины №485
Обводненность, %
Добыча жидкости, м3/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис.3



Динамика основных показателей
реагирующей добыв.скважины №486
Обводненность, %
Добыча жидкости, м3/сут
Добыча нефти, т/сут
180,0
170,0
160,0
150,0
140,0
130,0
120,0
110,0
100,0
90,0
80,0
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
20,0
19,0
18,0
17,0
16,0
15,0
14,0
13,0
12,0
11,0
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9,0
8,0
7,0
6,0
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20-янв-2014
23-янв-2014
26-янв-2014
29-янв-2014
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 4.

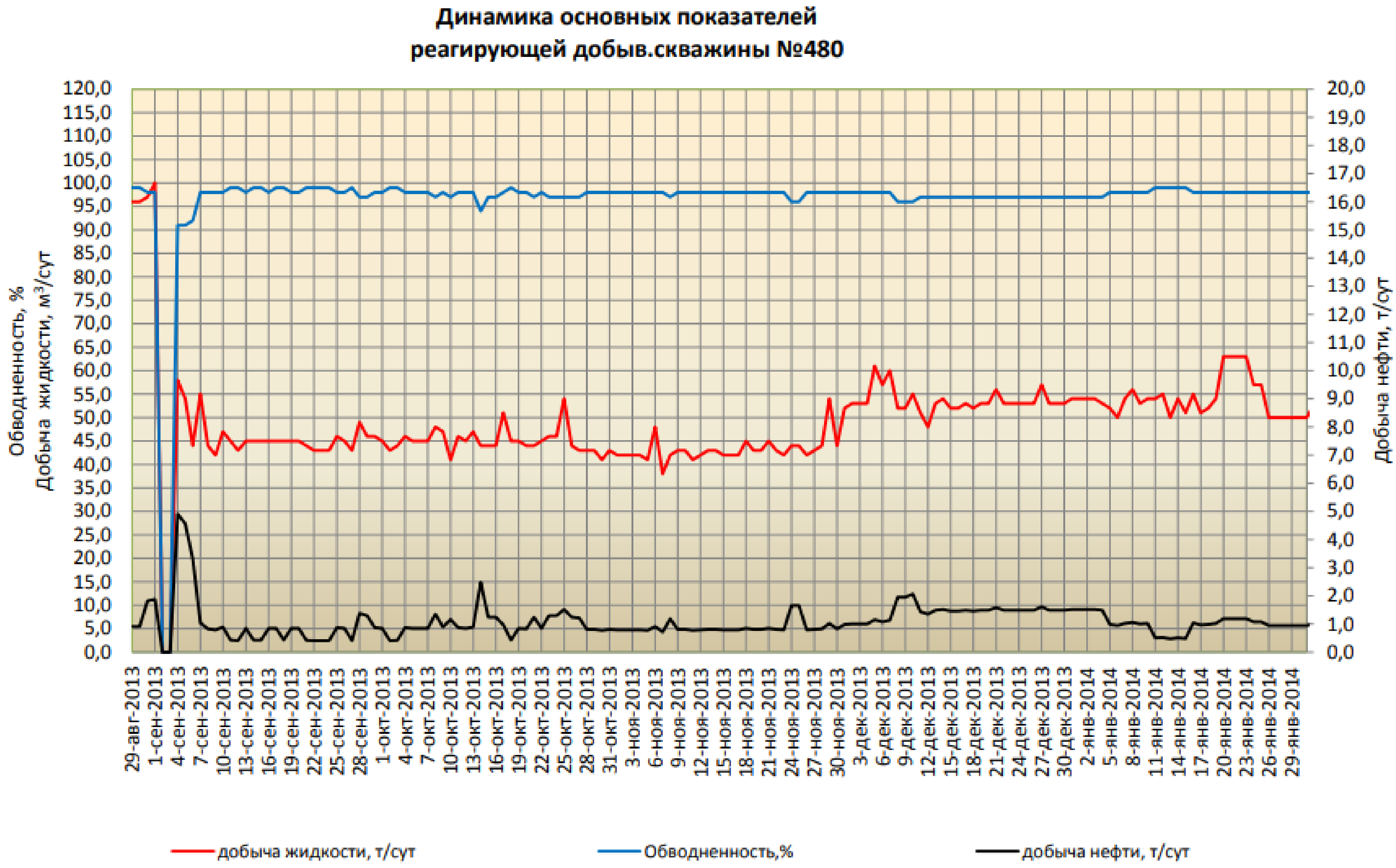
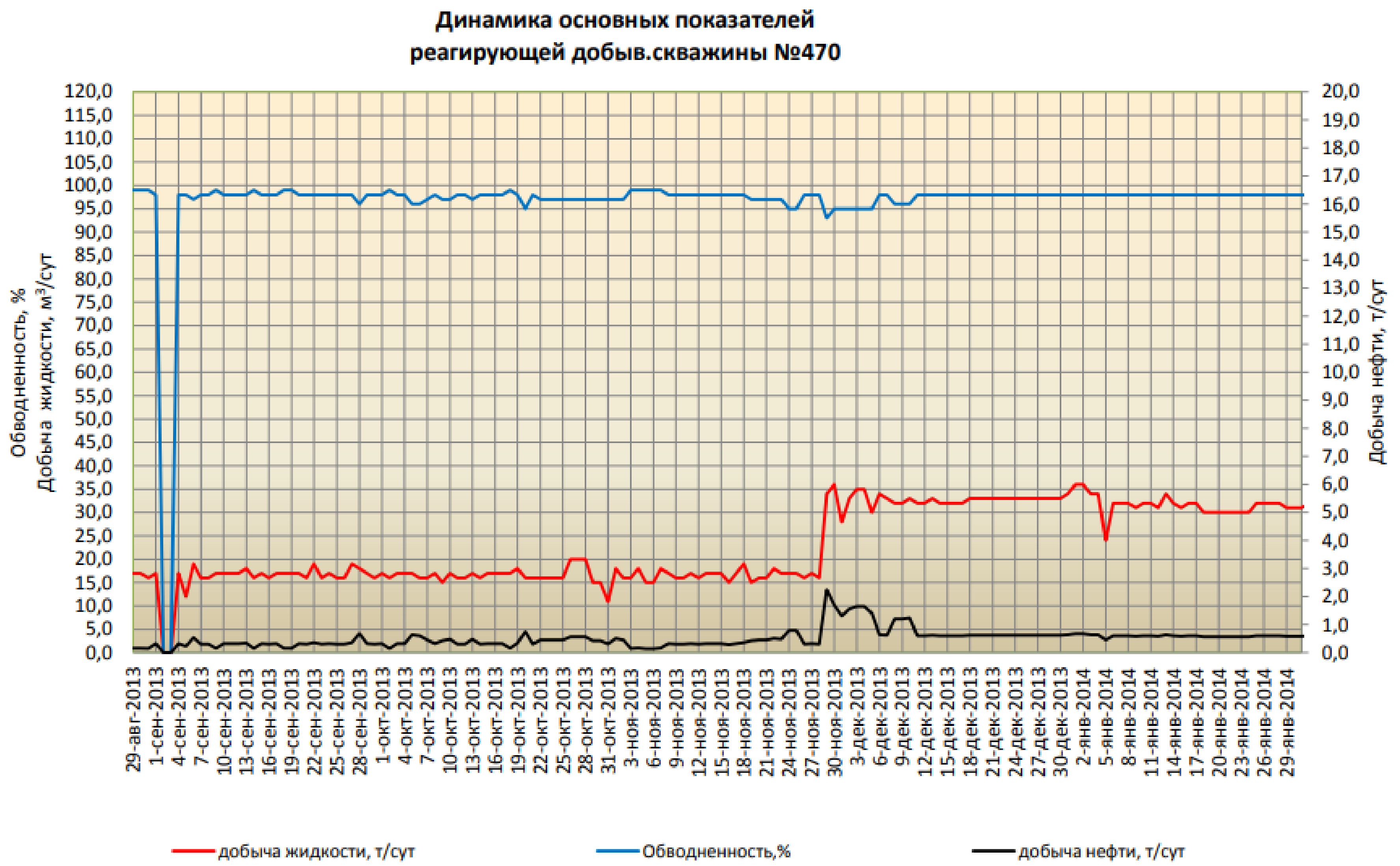
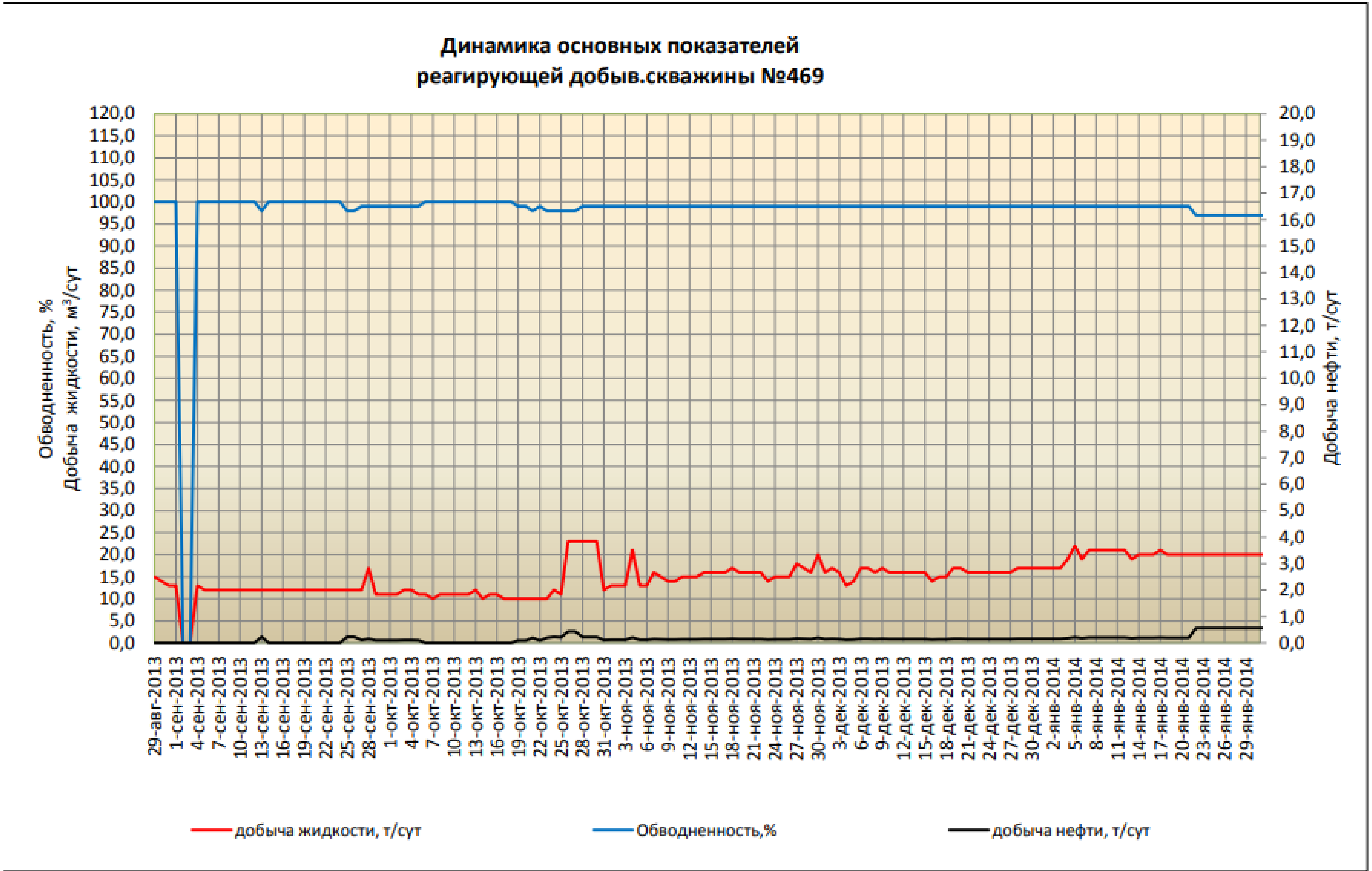

Динамика основных показателей
реагирующей добыв.скважины №480
Обводненность, %
Добыча жидкости, м³/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 5.



Динамика основных показателей
реагирующей добыв.скважины №470
Обводненность, %
Добыча жидкости, м³/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 6.



Динамика основных показателей
реагирующей добыв.скважины №469
Обводненность, %
Добыча жидкости, м3/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 7.

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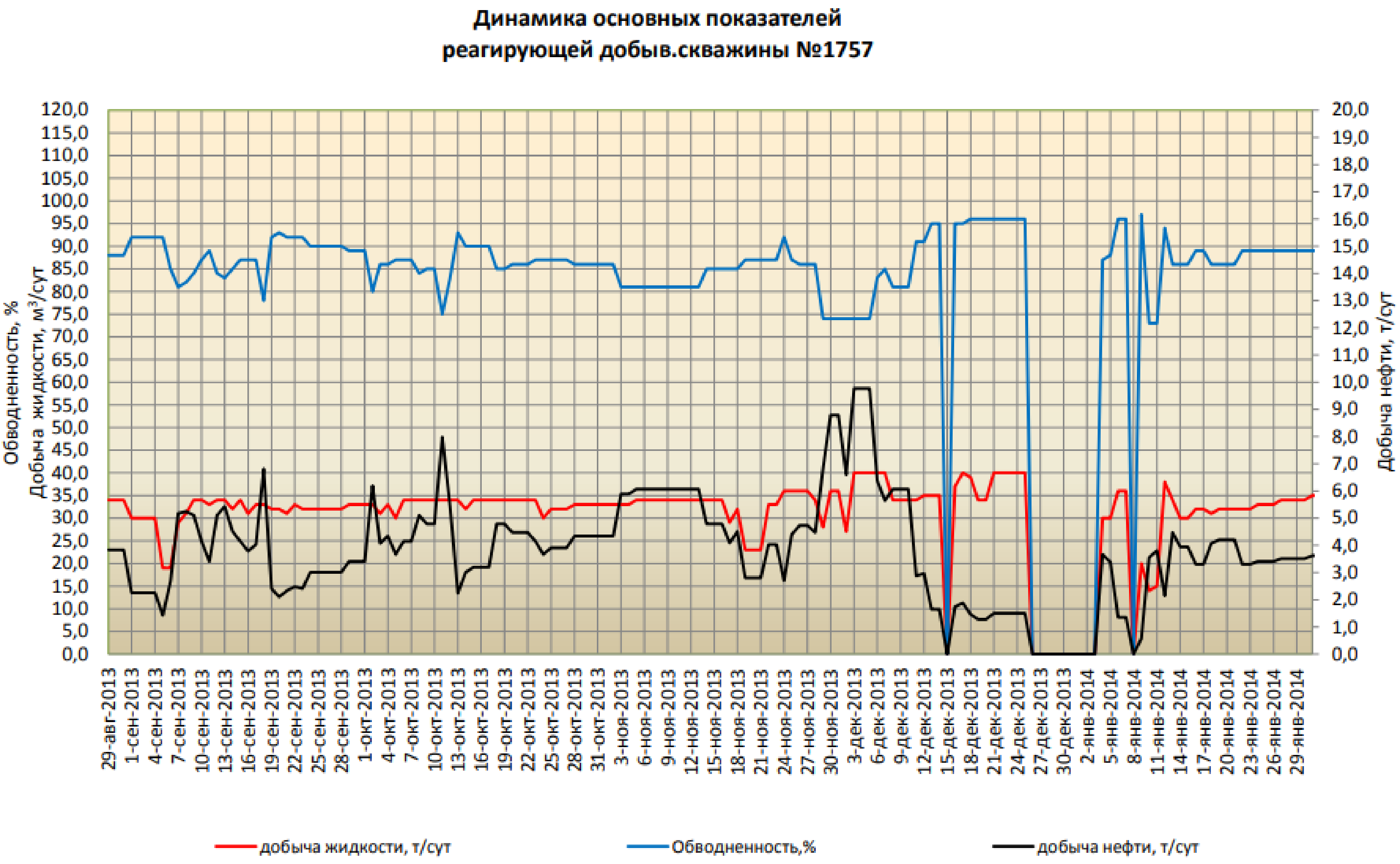
Динамика основных показателей
реагирующей добыв.скважины №1757
Обводненность, %
Добыча жидкости, м³/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 8

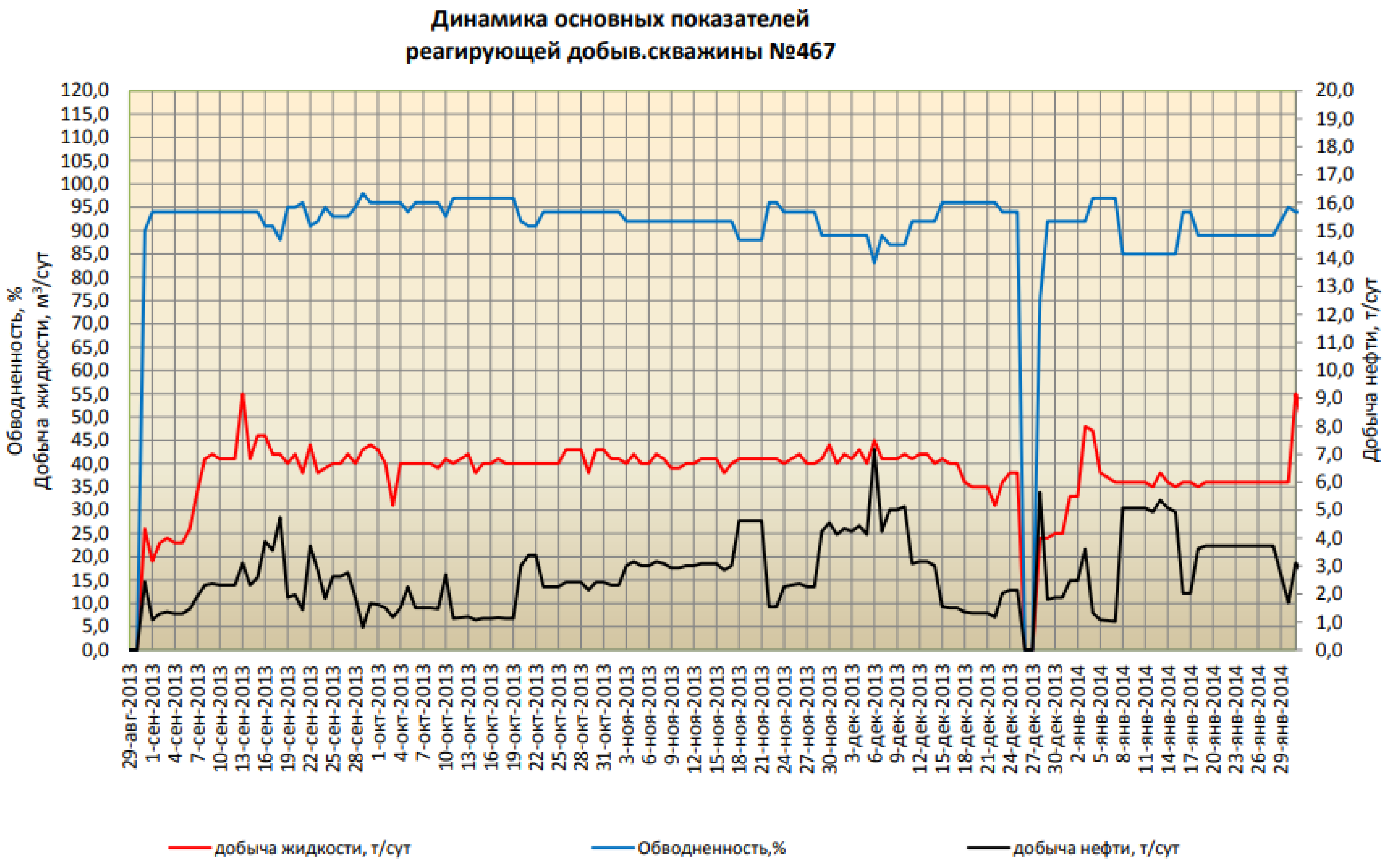
Динамика основных показателей
реагирующей добыв.скважины №467
Обводненность, %
Добыча жидкости, м³/сут
Добыча нефти, т/сут
добыча жидкости, т/сут
Обводненность,%
добыча нефти, т/сут

Рис. 9.

13 References

1. Report on the study of the injectivity profile of the field X LLP "X"
2. Code of the Republic of Kazakhstan dated December 27, 2017 No. 125-VI "On Subsoil and subsoil use ";
3. "Uniform rules for the rational and integrated use of mineral resources",approved by order of the Minister of Energy of the Republic of Kazakhstan dated June 15 2018 # 239
4. "Rules for ensuring industrial safety for hazardous production facilities of the oil and gas industries ",approved by order of the Minister for Investment and Development of the Republic Kazakhstan dated December 30, 2014 No. 355;
5. "Environmental Code of the Republic of Kazakhstan" No. 212-III dated 09.01.2007 (as amended and additions dated 01/02/2021)