



Original article

EDN: RXHRBC

DOI: 10.21285/2686-9993-2026-49-1-7

## Improving well cementing efficiency in complex mining and geological conditions through the use of a sub-preventer sealer

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**Abstract.** The purpose of this work is to improve the safety and cost-effectiveness of the counter-cementing process of casing strings under conditions of lost circulation and the risk of gas, oil, and water shows, using the Yurubcheno-Tokhomskeye field as an example. The causes of frequent failures of the universal preventer during the counter-cementing with the closed universal preventer in order to create a vacuum effect were analysed. The study was given to the geological and technical conditions of the Yurubcheno-Tokhomskeye field, which led to 28 cases of equipment failure in 2023–2024. The design and operation principle of the sub-preventer sealer as an alternative technological solution were considered. A comparative technical and economic assessment of the sealer implementation was performed and the discounted cash flow, payback period, and profitability index were calculated. It was determined that the main cause of universal preventer failures was due to the operation of the sealing element in an aggressive cement slurry environment under the influence of a vacuum. It led to the loss of the second safety barrier. The proposed solution (to install a sub-preventer sealer between the casing head flange and the blowout preventer crosspiece) allows to seal the annular space of the casing string without the use of a universal preventer. The feasibility study showed that a one-time investment of 16 million rubles for equipping 5 drilling rigs covers the expenses during the first year of operation providing significant annual savings by eliminating the repair cost of the drilling rigs. The introduction of a sub-preventer sealer makes it possible to eliminate a major technological risk of second barrier failure during counter-cementing, thereby increasing the industrial safety of work. The technical solution is economically feasible since its yield index is <1 and its discounted payback period is less than a year. It can be recommended for use in fields with similar complex mining and geological conditions.

**Keywords:** counter-cementing, absorption, gas, oil, and water show, universal preventer, sub-preventer sealer, safety, economic efficiency, Yurubcheno-Tokhomskeye field

**For citation:** Sobennikov V.O., Gura E.N., Sverkunov S.A., Vakhromeev A.G., Buglov A.N., Gladyshev D.D. Improving well cementing efficiency in complex mining and geological conditions through the use of a sub-preventer sealer. *Earth sciences and subsoil use*. 2026;49(1):84-95. <https://doi.org/10.21285/2686-9993-2026-49-1-7>.

Научная статья  
УДК 622.248

## Повышение эффективности цементирования скважин в сложных горно-геологических условиях за счет применения подпревенторного герметизатора

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**Резюме.** Целью данной работы являлось повышение безопасности и экономической эффективности процесса встречного цементирования обсадных колонн в условиях поглощения промывочной жидкости и риска газонефтеводопроявлений на примере Юрубчено-Тохомского месторождения. В ходе исследования проведен анализ причин частого выхода из строя универсального превентора при выполнении технологии встречного цементирования с закрытым универсальным превентором для создания вакуумного эф-



фекта. Изучены геолого-технические условия Юрубчено-Тохомского месторождения, приведшие к 28 случаям отказа оборудования в 2023–2024 гг. Рассмотрены конструкция и принцип работы подпревенторного герметизатора как альтернативного технологического решения. Выполнена сравнительная технико-экономическая оценка внедрения герметизатора с расчетом дисконтированного денежного потока, срока окупаемости и индекса доходности. Установлено, что основная причина отказа универсального превентора – работа уплотнительного элемента в агрессивной среде цементного раствора под воздействием вакуума, что приводит к потере второго барьера безопасности. Предложенное решение – установка подпревенторного герметизатора между фланцем колонной головки и крестовиной превентора противовыбросового оборудования – позволяет герметизировать затрубное пространство обсадной колонны без использования универсального превентора. Технико-экономическая оценка показала, что единовременные инвестиции в размере 16 млн руб. на оснащение 5 буровых установок окупаются в течение первого года эксплуатации, обеспечивая значительную годовую экономию за счет исключения затрат на ремонт универсального превентора. Внедрение подпревенторного герметизатора позволяет устранить ключевой технологический риск – отказ второго барьера при встречном цементировании, тем самым повышая промышленную безопасность работ. Техническое решение экономически целесообразно, характеризуется индексом доходности менее 1 и дисконтированным сроком окупаемости менее года, может быть рекомендовано для применения на месторождениях со схожими сложными горно-геологическими условиями.

**Ключевые слова:** встречное цементирование, поглощение, газонефтеводопроявление, универсальный превентор, подпревенторный герметизатор, безопасность, экономическая эффективность, Юрубчено-Тохомское месторождение

**Для цитирования:** Собенников В.О., Гура Э.Н., Сверкунов С.А., Вахромеев А.Г., Буглов А.Н., Гладышев Д.Д. Повышение эффективности цементирования скважин в сложных горно-геологических условиях за счет применения подпревенторного герметизатора // Науки о Земле и недропользование. 2026. Т. 49. № 1. С. 84–95. <https://doi.org/10.21285/2686-9993-2026-49-1-7>.

## Introduction

The construction of wells in complex mining and geological conditions characterized by the presence of abnormally permeable fractured reservoirs is associated with high technological risks [1–15]. One of the most critical risks is the loss of drilling and cement slurry, which leads to a decrease in the hydrostatic level in the wellbore and creates prerequisites for gas, oil, and water shows [7, 10, 16–20]. In fields such as the Yurubcheno-Tokhomskeye field, the standard operation of direct casing cementing often proves ineffective due to the lack of cement slurry return at the wellhead.

To ensure annular isolation under such conditions, a counter-cementing technology is employed using a closed universal preventer (hydraulic universal preventer, HUP) and the injection of foam cement slurry [9, 13]. This method creates a vacuum effect and forces the cement slurry into the formation [6]. However, practice shows that this technique has a significant drawback: the cement slurry and the back-pressure regime cause rapid wear and failure of the rubber sealing element of the HUP. The loss of HUP tightness after cementing means the effective absence of the second (external) safety barrier, which poses a direct threat of an uncontrolled blowout [16] during subsequent penetration of productive horizons.

## Materials and methods

Let us consider the process of drilling fluid loss in different reservoir types. Drilling fluid loss is the loss of a certain amount of drilling or cement slurry as a result of its flow from the wellbore into the formation.

Different reservoir types have distinct flow and storage properties, which determine the specific nature of losses inherent to each reservoir type [11]. An abnormally permeable carbonate reservoir (Fig. 1, a) is composed of fractured carbonate rocks, in which fractures have a vertical and subvertical orientation [14]. This significantly complicates the drilling process in such a reservoir due to the occurrence of catastrophic losses without circulation return. For comparison, in a terrigenous reservoir [14] (Fig. 1, b), which is composed of sandy rocks and is less permeable, the flow and storage properties of an abnormally permeable reservoir ensure a high probability of a critical drop in the drilling fluid level in the wellbore [16].

*The main factor in the occurrence of gas, oil, and water shows.* The occurrence of gas, oil, and water shows is associated with a decrease in the hydrostatic level of drilling fluid in the wellbore due to lost circulation in the productive horizon [16].



a

b

**Fig. 1. Reservoir (photo made by the authors of the article):**

a – carbonate reservoir; b – terrigenous collector

**Рис. 1. Коллектор (фото авторов статьи):**

a – коллектор карбонатного типа; b – коллектор терригенного типа

Due to the extremely high flow and storage properties of the formation, the redistribution of bottomhole pressures in the “wellbore–formation” system takes a minimal amount of time. In practice, this is accompanied by a lightning-fast transition of the well from lost circulation to a gas, oil, and water show (Fig. 2).

The main measures to prevent gas, oil, and water shows are:

– Drilling using a rotary blowout preventer (rotary universal preventer, RUP) [12];

– Maintaining the static level above the critical level during tripping operations;

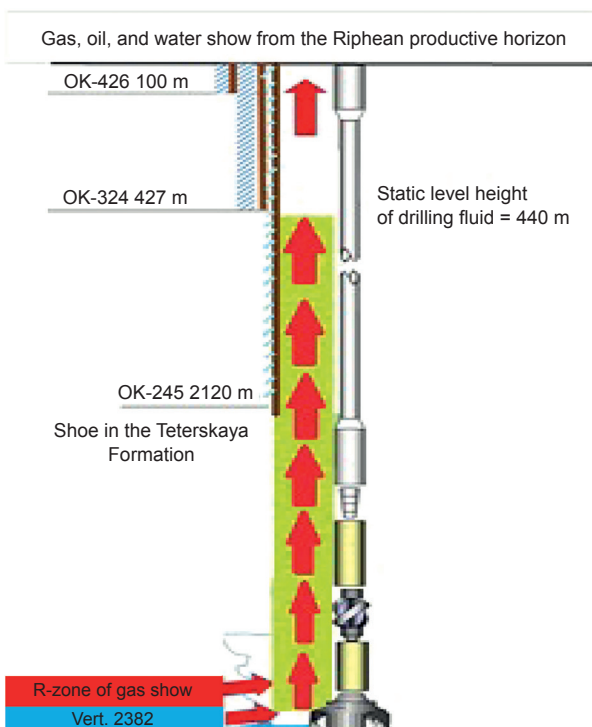
– Careful monitoring of drilling fluid volume in the drilling rig tanks.

*Well casing process.* The well casing process at the Yurubcheno-Tokhomskoeye field consists of the following operations:

- 1) Pumping a buffer;
- 2) Mixing and pumping a foam cement slurry [9];
- 3) Launching the cementing plug;
- 4) Pumping the displacement fluid;
- 5) Pressure testing the casing string;
- 6) Performing counter-cementing [17];
- 7) Creating a pressure of 100 atm in the casing string;
- 8) Connecting the cementing unit to the casing head;
- 9) Closing the universal preventer (HUP);
- 10) Checking injectivity;
- 11) Pumping the foam cement slurry [9];
- 12) Final stage – waiting on cement (WOC) with the HUP closed.

After WOC, a loss of HUP functionality is often detected (Fig. 3), specifically the failure of the sealing element. The cause of this incident is a violation of the universal preventer’s operating characteristics due to the equipment being used in an aggressive working environment (cement slurry) and operating under a vacuum effect caused by the well back-pressure regime.

In total, for 2023 and 2024, 28 cases of HUP failure were recorded at the Yurubcheno-



**Fig. 2. Occurrence of a gas, oil, and water show (drawing made by the authors of the article)**

**Рис. 2. Возникновение газонефтеводопроявления (рисунок сделан авторами статьи)**



a



b

**Fig. 3. Damaged sealing element (photo made by the authors of the article):**

*a – top view; b – bottom view*

**Рис. 3. Поврежденный уплотнительный элемент (фото авторов статьи):**

*a – вид сверху; b – вид снизу*

Tokhomskeye field after counter-cementing operations.

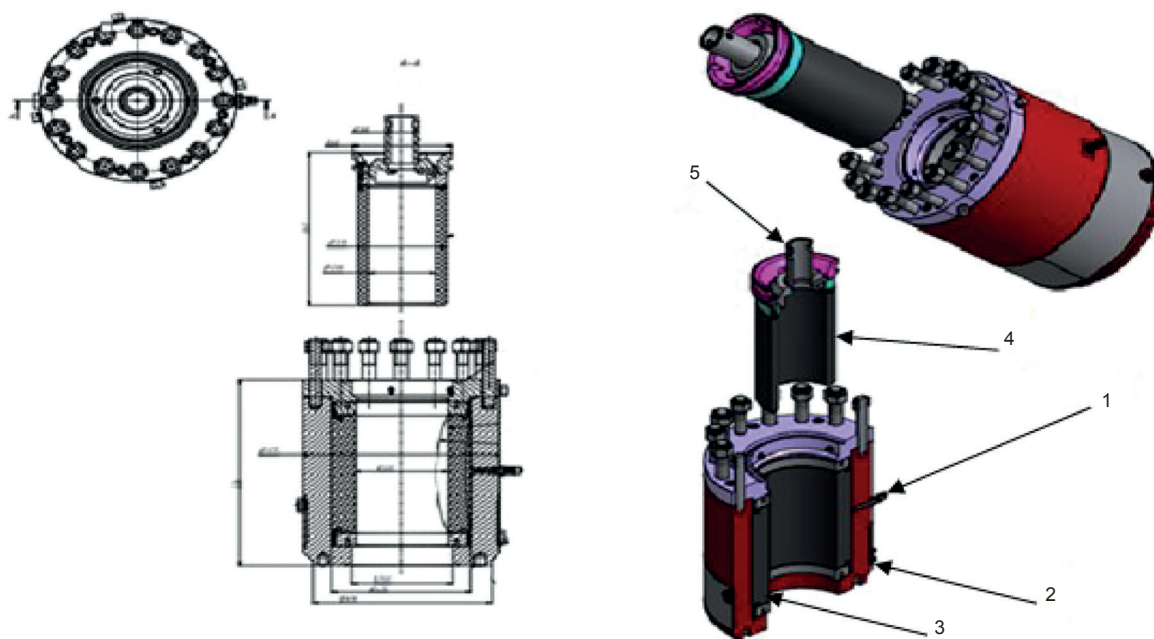
Due to the frequent failure of the rubber sealing element of the HUP after counter-cementing, there is a risk of being left without the second barrier, which can lead to risks associated with danger to human life and the loss of expensive equipment. As a means of wellhead sealing for counter-cementing, the use of a RUP could be considered. However, during the pumping of the cement slurry, there is a risk of it getting onto the lower installed sealing element of the HUP, and due to insufficient flushing during WOC, the cement slurry will harden on the HUP sealing element, which will also negatively affect its subsequent operation. It should also be noted that it is not possible to abandon the sealing of the annulus during counter-cementing, as repeated counter-cementing would need to be performed several times, which is impractical and would lead to longer well construction times and a significant increase in financial costs.

### Results and discussion

A solution to this problem may be the use of a sub-preventer sealer (Fig. 4), installed be-

tween the casing head flange and the blowout preventer crosspiece of the blowout preventer equipment. To date, the authors have not recorded the use of any kind of sub-preventer sealers for counter-cementing at other fields. The sub-preventer sealer presented in this article is a newly developed piece of equipment that is not yet in serial production. This equipment has been developed to address cementing challenges in complex mining and geological conditions of oil and gas fields in the south of the Siberian Platform.

The sub-preventer sealer consists of the following components: a metal body (2), a nozzle (1) for injecting oil using a manual hydraulic pump, and a sealing element (3) for the 245 mm casing string located inside the body. That is, pressurized oil enters the chamber between the sealer body and the sealing element, causing the membrane to compress around the casing string. After completing the counter-cementing operations for the 245 mm casing string and re-assembling the blowout preventer equipment, a special wrench (5) is used to lower the cup seal (sealing element (4)) for the 178 mm casing



**Fig. 4. Sub-preventer sealer (drawing made by the authors of the article):**

1 – nozzle; 2 – sub-preventer sealer body; 3 – sealing element for OK-245; 4 – sealing element for OK-178; 5 – wrench for installing the sealing element for OK-178

**Рис. 4. Подпревенторный герметизатор (рисунок сделан авторами статьи):**

1 – штуцер; 2 – корпус подпревенторного герметизатора; 3 – уплотнительный элемент под ОК-245; 4 – уплотнительный элемент под ОК-178; 5 – ключ для установки уплотнительного элемента под ОК-178

string onto the sealer, engage it into the appropriate grooves, and then retrieve the wrench to the surface. According to preliminary estimates, the installation will take 5–10 minutes. Drilling for the production casing will be carried out with two membranes installed on the sealer. During counter-cementing, the operating principle is the same as for the intermediate casing string, except that the first membrane will press against the second, thereby fully compressing the 178 mm casing string. There is no need to close the HUP in this case.

The inner diameter of the first membrane for the 245 mm casing string in its inactive state is 320 mm; the inner diameter of the second membrane for the 178 mm casing string in its inactive state is 230 mm.

Figure 5 shows the installation location of the sub-preventer sealer.

An alternative to the sub-preventer sealer could be a single-ram preventer with rams for a diameter of 245/178 mm.

Disadvantages:

– The cost is 2.5 times higher compared to the sub-preventer sealer;

– Changing the rams takes significantly more time than changing the sealing element of the sub-preventer sealer;

– Pressure testing is required, as it is blowout preventer equipment;

– Not suitable for all drilling rigs (e.g., drilling rig BU-2900/200).

The sub-preventer sealer has the following advantages:

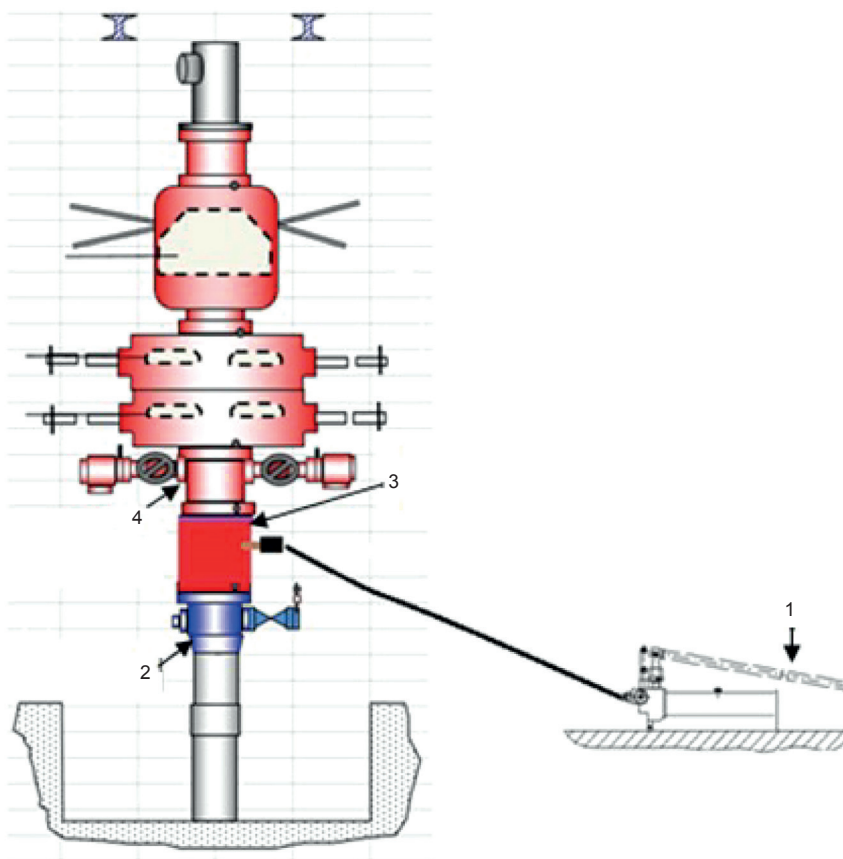
– No need to use a HUP;

– No risk of failure of the second barrier; consequently, all blowout safety regulations are complied with;

– Cementing is performed with productive horizons already open and gas-saturated, where after completion of counter-cementing the level drops below critical and a gas, oil, and water show occurs, while the HUP remains operational.

The key point is safety. The sub-preventer sealer will help preserve all expensive drilling equipment in the event of a gas, oil, and water show and, undoubtedly, the health and lives of field personnel.

The economic effect will be discussed next. The calculation was performed using the example



**Fig. 5. Installation location of the sub-preventer sealer (drawing made by the authors of the article):**

1 – hydraulic hand pump; 2 – casing head; 3 – sub-preventer sealer;  
 4 – blow-out preventer crosspiece

**Рис. 5. Место установки подпревенторного герметизатора (рисунок сделан авторами статьи):**

1 – насос ручной гидравлический; 2 – колонная головка; 3 – подпревенторный герметизатор;  
 4 – крестовина противовыбросового оборудования

of Drilling Company X operating in a field with an abnormally permeable reservoir. There are five drilling rigs in operation:

- Cost of the sub-preventer sealer, including pilot tests/studies – 10 million rubles;
- Cost of the sub-preventer sealer during mass production, per unit – 1 million rubles;
- Cost of the rubber sealing element for the HUP, per unit – 360 thousand rubles;
- Cost of the rubber sealing element for the sealer, per unit – 100 thousand rubles;
- Additional counter-cementing without annular sealing, per operation – 350 thousand rubles.

Expenditures in 2025 for replacing the HUP sealing element will amount to 18 million rubles.

Costs for purchasing the sub-preventer sealer for five rigs (of Drilling Company X) operating in a field with an abnormally permeable reservoir,

including pilot tests/studies – 16 million rubles (of which 10 million rubles are for conducting the pilot tests/studies, 5 million rubles for purchasing five sealers, and 1 million rubles for purchasing ten spare rubber seals). It is also worth mentioning the importance of annular sealing during counter-cementing. If this is not done, repeated counter-cementing will need to be performed 2–3 times. Figure 6 shows the payback curve of the sub-preventer sealer, characterizing savings of 35.7 million rubles over five years and a discounted payback period within the first year. Table 1 presents the investment costs for the project, Table 2 indicates the annual cost savings from introducing the sub-preventer sealer into production. Table 3 presents the operating cash flow, taking into account the discount rate, along with the profitability index and payback period [8].

**Table 1. Project investment costs**  
**Таблица 1. Инвестиционные затраты на проект**

Name	Amount with VAT, rub.
Purchase of equipment: sub-preventer sealer – 5 pcs. (including spare parts, tools, accessories, and pilot tests/studies)	16,000,000
Total	16,000,000

Note. SPTA – spare parts, tools, and accessories. PTS – pilot tests/studies.

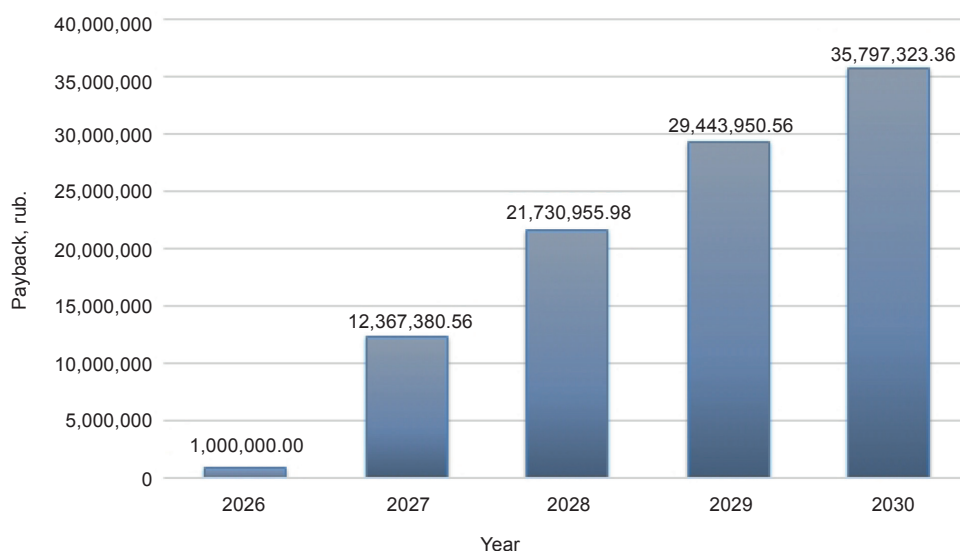
**Table 2. Annual cost savings**  
**Таблица 2. Экономия затрат в год**

Name	Amount
Number of rubber replacements per year, pcs.	50
Cost of HUP rubber replacement, rub.	360,000
Annual cost of SPTA for the sub-preventer sealer for 5 drilling rigs, rub.	1,000,000
Annual HUP repair costs, rub.	18,000,000
Экономия в год	17,000,000

Note. HUP – hydraulic universal preventer.

**Table 3. Operating cash flow**  
**Таблица 3. Операционный денежный поток**

Indicator	2026	2027	2028	2029	2030
Operating cash flow, rub.	1,000,000	17,000,000	17,000,000	17,000,000	17,000,000
Investment cash flow, rub.	16,000,000	–	–	–	–
Useful life, years	5				
Depreciation charges, rub.	–	3,200,000	3,200,000	3,200,000	3,200,000
Project cash flow, rub.	1,000,000	13,800,000	13,800,000	13,800,000	13,800,000
Cumulative project cash flow, rub.	1,000,000	14,800,000	28,600,000	42,400,000	56,200,000
Non-discounted payback period, years	Less than 1 year				
Refinancing rate, %	15.5	15.5	15.5	15.5	15.5
Inflation, %	5.9	5.9	5.9	5.9	5.9
Discount rate, %	21.4	21.4	21.4	21.4	21.4
Discount factor, abs. value	1.00	0.82	0.68	0.56	0.46
Discounted cash flow, rub.	1,000,000	11,367,381	9,363,575	7,712,995	6,353,373
Cumulative discounted cash flow, rub.	1,000,000	12,367,381	21,730,956	29,443,951	35,797,323
Discounted operating cash flow + depreciation, abs. value	1,000,000	17,203,295	14,734,839	12,701,515	11,026,619
Profitability index	3.54				
Discounted payback period, years	Less than 1 year				



**Fig. 6. Payback schedule of the sub-preventer sealer for drilling company X (graph made by the authors of the article)**

**Рис. 6. График окупаемости подпревенторного герметизатора для бурового предприятия X (рисунок сделан авторами статьи)**

Using the Yurubcheno-Tokhomskeye field as an example, a thorough study was conducted. Let us now proceed to the concluding part.

### Conclusion

The introduction of the sub-preventer sealer is a key solution for improving the safety and efficiency of well counter-cementing under lost circulation conditions. It eliminates the main drawback of the conventional technology – wear

of the universal preventer sealing element when used for wellhead sealing – thereby preserving both safety barriers. The use of alternatives (HUP, RUP) is impractical due to the high technological risks of subsequent inoperability of this equipment, which is directly related to blowout safety. Furthermore, the use of RUP and HUP during cementing would lead to additional significant financial and time costs for the drilling company.

### References

1. Foroushan H.K., Lund B., Ytrehus Ja.D., Saasen A. Cement placement: an overview of fluid displacement techniques and modelling. *Energies*. 2021;14(3):573. <https://doi.org/10.3390/en14030573>.
2. Mahmoud A.A., Abdelaal A., Adjei S., Elkatatny S. Foamed cement applications in oil industry based on field experience: a comprehensive review. *ACS Omega*. 2024;9:9. <https://doi.org/10.1021/acsomega.3c07580>.
3. Sayindla S., Lund B., Ytrehus J.D., Saasen A. Hole-cleaning performance comparison of oil-based and water-based drilling fluids. *Journal of Petroleum Science and Engineering*. 2021;159:49-57. <https://doi.org/10.1016/j.petrol.2017.08.069>.
4. Veliyev E.F., Aliyev A.A. Comparative analysis of the geopolymer and Portland cement application as plugging material under conditions of incomplete displacement of drilling mud from the annulus. *SOCAR Proceedings*. 2022;1:108-115. <https://doi.org/10.5510/OGP20220100637>.
5. Wang H., Huang H., Bi W., Ji G., Zhou B., Zhuo L. Deep and ultra-deep oil and gas well drilling technologies: progress and prospect. *Natural Gas Industry*. 2022;9(2):141-157. <https://doi.org/10.1016/j.ngib.2021.08.019>.
6. Bykov V.V., Paleev S.A., Akhmetzyanov R.R., Zaharenkov A.V., Zakirov N.N. An integrated approach to cementing casing strings in difficult conditions of fields in Eastern Siberia. *Oil Industry*. 2024;8:58-61. (In Russ.). <https://doi.org/10.24887/0028-2448-2024-8-58-61>.
7. Darvish S. Achieving zonal isolation in the second largest oil field in the world: decade of training (Rumaila field, Iraq). In: *SPE/IADC Drilling Conference*. OnePetro. 2025.
8. Diachenko O.I. The method of oil and gas fields operational efficiency management. *Scientific Journal Economic Sciences*. 2016;12:76-82. (In Russ.).
9. Zalivin V.G. Resource-saving technologies of foam application in wells drilling. *Onshore and offshore oil and gas well construction*. 2025;8:43-49. (In Russ.).
10. Ismagilova E.R. Development the self-healing concept for well cement support integrity maintenance. theory and practice. *Kazakhstan Journal for Oil and Gas Industry*. 2024;6(1):64-73. <https://doi.org/10.54859/kjogi108662>.



11. Kryuchkov D. O., Pivovarov A. V., Kuznetsova L. S., Kizimov P. L. Real time seismogeological analysis while drilling is the first step to oilfield development efficiency. *Oilfield engineering*. 2024;4:34-42. (In Russ.).
12. Legostaev A. M., Khairullin B. Y., Vityazev O. L. *Rotary mouth sealer*. Patent RF, no. 2684261; 2019. (In Russ.).
13. Nersesov S. V., Mosienko V. G., Gasumov R. A., Chernukhin V. I., Ostap O. S., Minlikaev V. Z., Klimanov A. V. *Method of stepwise drilling of a well under conditions of abnormally low reservoir pressures in the absorption zone*. Patent RF, no. 2188302; 2002. (In Russ.).
14. Pivovarov A. V., Kolesov V. A., Kalistratov S. A., Zagrivniy F. A., Mishakov M. V. Influence of geological conditions on wear-out of the bits in the Riphean deposits of the Yurubcheno-Tokhomskoye field. *Oil Industry*. 2022;1:50-53. (In Russ.). <https://doi.org/10.24887/0028-2448-2022-1-50-53>.
15. Pivovarov A. V., Pleshko N. N., Filatova V. P., Kryuchkov D. O. Optimization of horizontal well drilling in carbonate reservoirs of eastern Siberia: results from the application of seismic-geological analysis. *Oil Industry*. 2025;5:94-98. (In Russ.). <https://doi.org/10.24887/0028-2448-2025-5-94-98>.
16. Ryzhenko V. Iu. Russian oil industry: state and problems. *Perspectives of Science and Education*. 2014;1:300-308. (In Russ.).
17. Samsonenko N. V., Mnatsakanov V. A., Mansurov M. N., Potapov A. G. Problems of primary cementing of horizontal gas production wells at the Kharasaveyskoe gas-condensate field. *Onshore and offshore oil and gas well construction*. 2026;1:37-43. (In Russ.).
18. Chernyshov S. E., Ashikhmin S. G., Kashnikov Yu. A., Savich A. D., Mosin A. V., Chulrlov A. S. Evaluation of the cement sheath safety after shaped charge perforation considering the criterion of cement stone destruction. *Oil Industry*. 2021;6:50-53. (In Russ.). <https://doi.org/10.24887/0028-2448-2021-6-50-53>.
19. Shamilo V. M., Abdullayev A. I., Guliyev I. B., Safarov Ya. O., Shamilo F. V. The influence of nanostructured cement slurry on the quality of well cementing. *Oil Industry*. 2025;3:52-55. (In Russ.). <https://doi.org/10.24887/0028-2448-2025-3-52-55>.
20. Shut K. F., Khrabrov V. A. Study of hollow microspheres stability to the alkaline environment of cement slurry. *Construction of oil and gas wells on land and sea*. 2026;2:39-43.

#### Список источников

1. Foroushan H. K., Lund B., Ytrehus J. D., Saasen A. Cement placement: an overview of fluid displacement techniques and modelling // *Energies*. 2021. Vol. 14. Iss. 3. P. 573. <https://doi.org/10.3390/en14030573>.
2. Mahmoud A. A., Abdelaal A., Adjei S., Elkhatny S. Foamed cement applications in oil industry based on field experience: a comprehensive review // *ACS Omega*. 2024. Vol. 9. № 9. <https://doi.org/10.1021/acsomega.3c07580>.
3. Sayindla S., Lund B., Ytrehus J. D., Saasen A. Hole-cleaning performance comparison of oil-based and water-based drilling fluids // *Journal of Petroleum Science and Engineering*. 2021. Vol. 159. P. 49–57. <https://doi.org/10.1016/j.petrol.2017.08.069>.
4. Veliyev E. F., Aliyev A. A. Comparative analysis of the geopolymer and Portland cement application as plugging material under conditions of incomplete displacement of drilling mud from the annulus // *SOCAR Proceedings*. 2022. № 1. P. 108–115. <https://doi.org/10.5510/OGP20220100637>.
5. Wang H., Huang H., Bi W., Ji G., Zhou B., Zhuo L. Deep and ultra-deep oil and gas well drilling technologies: progress and prospect // *Natural Gas Industry*. 2022. Vol. 9. Iss. 2. P. 141–157. <https://doi.org/10.1016/j.ngib.2021.08.019>.
6. Быков В. В., Палеев С. А., Ахметзянов Р. Р., Захаренков А. В., Закиров Н. Н. Комплексный подход к цементированию обсадных колонн в осложненных условиях месторождений Восточной Сибири // *Нефтяное хозяйство*. 2024. № 8. С. 58–61. <https://doi.org/10.24887/0028-2448-2024-8-58-61>.
7. Дарвиш С. Достижение зональной изоляции на втором по величине нефтяном месторождении в мире: десятилетие обучения (месторождение Румайла, Ирак) // Конференция SPE/IADC по бурению. OnePetro. 2025.
8. Дьяченко О. И. Методика управления операционной эффективностью эксплуатации нефтегазодобывающих компаний // *Экономические науки*. 2016. № 12. С. 76–82.
9. Заливин В. Г. Ресурсосберегающие технологии применения пены при бурении скважин // *Строительство нефтяных и газовых скважин на суше и на море*. 2025. № 8. С. 43–49.
10. Ismagilova E. R. Development the self-healing concept for well cement support integrity maintenance. theory and practice // *Kazakhstan Journal for Oil and Gas Industry*. 2024. Vol. 6. Iss. 1. P. 64–73. <https://doi.org/10.54859/kjogi108662>.
11. Крючков Д. О., Пивовар А. В., Кузнецова Л. С., Кизимов П. Л. Оперативный сейсмогеологический анализ при сопровождении бурения – первый шаг к эффективности разработки месторождения // *Нефтепромысловое дело*. 2024. № 4. С. 34–42.
12. Пат. № 2684261, Российская Федерация, E21B33/068. Герметизатор устьевого роторный / А. М. Легостаев, Б. Ю. Хайруллин, О. Л. Витязев. Заявл. 24.07.2018; опубл. 04.04.2019. Бюл. № 10.
13. Пат. № 2188302, Российская Федерация, E21B33/14. Способ ступенчатого цементирования скважины в условиях аномально низких пластовых давлений в зоне поглощения / С. В. Нерсесов, В. Г. Мосиенко, Р. А. Гасумов, В. И. Чернухин, О. С. Остапов, В. З. Минликаев, А. В. Климанов. Заявл. 19.09.2000; опубл. 27.08.2002. Бюл. № 24.
14. Пивовар А. В., Колесов В. А., Калистров С. А., Загривный Ф. А., Мишаков М. В. Влияние геологических условий на износ долот в интервале рифейских отложений Юрубчено-Тохомского месторождения // *Нефтяное хозяйство*. 2022. № 1. С. 50–53. <https://doi.org/10.24887/0028-2448-2022-1-50-53>.



15. Пивовар А.В., Плешко Н.Н., Филатова В.П., Крючков Д.О. Оптимизация бурения горизонтальных скважин в карбонатных коллекторах Восточной Сибири: результаты применения сейсмогеологического анализа // Нефтяное хозяйство. 2025. № 5. С. 94–98. <https://doi.org/10.24887/0028-2448-2025-5-94-98>.

16. Рыженко В.Ю. Нефтяная промышленность России: состояние и проблемы // Перспективы науки и образования. 2014. № 1. С. 300–308.

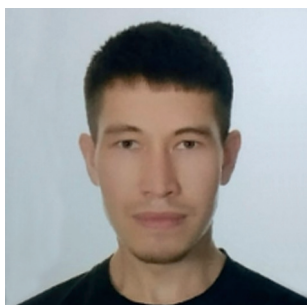
17. Самсоненко Н.В., Мнацаканов В.А., Мансуров М.Н., Потапов А.Г. Проблемы первичного цементирования газовых эксплуатационных горизонтальных скважин Харасавэйского ГКМ // Строительство нефтяных и газовых скважин на суше и на море. 2026. № 1. С. 37–43.

18. Чернышов С.Е., Ашихмин С.Г., Кашников Ю.А. Оценка сохранности крепи скважин после проведения кумулятивной перфорации с учетом критерия разрушения цементного камня // Нефтяное хозяйство. 2021. № 6. С. 50–53. <https://doi.org/10.24887/0028-2448-2021-6-50-53>.

19. Шамилов В.М., Абдуллаев А.И., Кулиев И.Б., Сафаров Я.О., Шамилов Ф.В. Влияние наноструктурированного цементного раствора на качество цементирования скважин // Нефтяное хозяйство. 2025. № 3. С. 52–55. <https://doi.org/10.24887/0028-2448-2025-3-52-55>.

20. Шуть К.Ф., Храбров В.А. Исследование устойчивости полых микросфер к щелочной среде тампонажного раствора // Строительство нефтяных и газовых скважин на суше и на море. 2026. № 2. С. 39–43.

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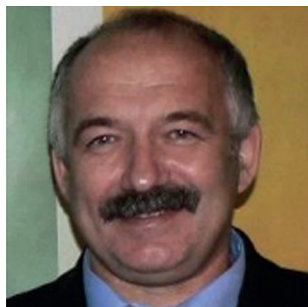
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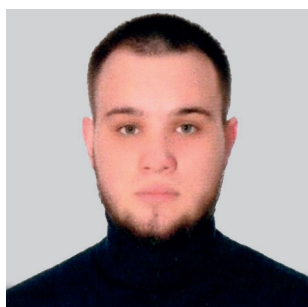
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### Conflict of interests / Конфликт интересов

The authors declare no conflict of interests.

Авторы заявляют об отсутствии конфликта интересов.

*The final manuscript has been read and approved by all the co-authors.*

*Все авторы прочитали и одобрили окончательный вариант рукописи.*

### Information about the article / Информация о статье

The article was submitted 04.03.2026; approved after reviewing 17.03.2026; accepted for publication 23.03.2026.

Статья поступила в редакцию 04.03.2026; одобрена после рецензирования 17.03.2026; принята к публикации 23.03.2026.