International Journal of Materials Science and Applications
2026, Vol. 15, No. 5, pp. 175–180
https://doi.org/10.11648/j.ijmsa.20261505.12

Review Article

Development Trends in the Market of Pipe Made from Alternative Materials in the Oil and Gas Industry

Maxim Valeryevich Bogatov[1, 2, *], Perov Kirill Alekseevich[1]

[1]Limited Liability Company, Research Center 'Nemetall', Samara, Russia

[2]Department of Metal Science, Powder Metallurgy, and Nanomaterials, Samara State Technical University, Samara, Russia

Abstract

The article examines the current state of pipeline transportation in the oil and gas industry of the Russian Federation. It is shown that, despite the high share of the oil and gas sector in the country's GDP and the significant length of pipeline systems (250–285 thousand km), corrosion remains a key problem, causing up to 85% of failures and up to 40 thousand accidents annually. One of the most promising areas for combating corrosion is the introduction of polymer-reinforced pipes (PRP), whose production and operation volumes, according to SIBUR LLC, will double by 2030. The design features of PRP (liner, reinforcing layer, outer sheath), their advantages over steel pipes (corrosion and erosion resistance, lower weight, reduced hydraulic resistance and deposits) and technological applications (oil gathering pipelines, reservoir pressure maintenance systems, flow lines) are analyzed. Examples of domestic manufacturers and the geography of PRP implementation are provided, as well as foreign case studies (Indonesia, Tanzania, Libya, West Africa). It is noted that the existing regulatory framework (GOST R 59834-2021, GOST R 70623-2023, company standards) is of a framework nature, contains errors, and does not regulate methods for diagnosing and assessing the residual life of PRP during operation. The necessity of developing a methodology for technical diagnostics of polymer-reinforced pipelines is substantiated. It is indicated that ongoing research, including the testing of acoustic emission and vibroacoustic methods, creates the basis for the preparation of a state standard in the field of PRP diagnostics.

Keywords

Flexible Polymer-reinforced Pipes, Rigid Polymer-reinforced Pipes, Field Pipelines, Oil and Gas Industry, Resource Assessment, Corrosion Processes

1. Introduction

The fuel and energy complex (FEC) of the Russian Federation is an integral, fundamental, and systemically important part of the economy and gross domestic product (GDP) of the country. According to the latest data, the share of the oil and gas sector in the structure of the Russian Federation's GDP fluctuates between 35% and 40%, depending on energy prices [1]. To ensure an uninterrupted and high-quality cycle of extraction and transportation of hydrocarbon raw materials, certain safety measures must be observed. The foundation of the industrial safety system in the FEC is Federal Law No. 116-

*Correspondence: Maxim Valeryevich Bogatov (m.bogatov@nicnemetall.ru)

Received: 17 June 2026; **Accepted:** 5 November 2026; **Published:** 26 November 2026

Copyright: © The Author(s), 2026. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

FZ "On Industrial Safety of Hazardous Industrial Facilities" [2]. FEC facilities belong to the highest hazard classes, therefore their operation is particularly strictly regulated. Rostekhnadzor plays a key role in control, constantly updating regulations, licensing requirements, and risk indicators. Continuous capital investment is necessary to minimize the risk of emergency situations at oil and gas facilities. In addition, significant problems in the field of hydrocarbon production and transportation include a shortage of qualified personnel and physical deterioration of the infrastructure. While in the first case the problem lies in the constant modernization of regulatory acts on training and the slow implementation of modern technologies, in the second case there is significant deterioration of the existing pipeline arteries. Currently, the total length of various types of pipelines (metal construction) fluctuates in the range of 250-285 thousand kilometers [3]. The main complicating factor that leads to emergency situations is the occurrence of corrosion processes by various mechanisms (carbon dioxide, hydrogen sulfide, oxygen, biocorrosion). Failures due to this complicating factor reach approximately 85% of the total number of failures and up to 40 thousand accidents are recorded annually [4]. In order to eliminate or minimize emergency situations in the oil and gas industry, there are various types of protection against corrosion processes. Currently, the following protection methods are widely used: the use of insulating materials for metal (polymer coatings), electrochemical protection (cathodic, sacrificial protection), corrosion inhibitors, corrosion-resistant alloys, monitoring and diagnostics, and the use of pipes made of alternative materials [5-7]. All of these methods reduce or minimize corrosion processes. The last method of corrosion protection is actively developing and one of the most promising.

The use of pipes made of alternative materials is a new milestone in the development of pipeline transportation in the Russian Federation. Polymer-reinforced pipes (PRP) are a modern solution for the oil and gas industry. According to SIBUR, one of the giants in the production of raw materials for PRP manufacturing, by 2030 production volumes will double and pipeline construction in the Russian Federation will increase (Figure 1). The purpose of this work is to describe existing manufacturing plants, implementation experience (global and domestic experience), advantages of use, as well as a description of problematic issues in regulatory and technical documentation regarding the certification, construction and diagnostics of polymer-reinforced pipes in the oil and gas industry of the Russian Federation.

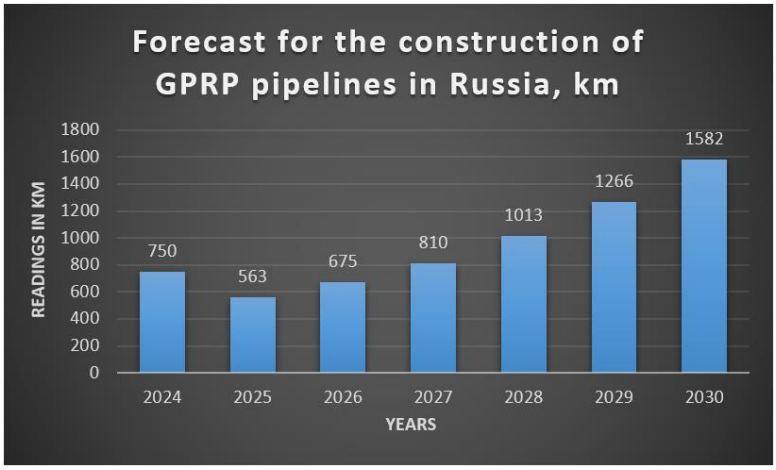


Figure 1. *Growth of production and operation according to SIBUR LLC [8].*

One of the main values of PRP is the ability to solve the main problem in the production and transportation of hydrocarbon raw materials - corrosion of the internal and external surfaces. The introduction and use of alternative materials leads to significant economic benefits at all stages from construction to operation of pipeline transport in the oil and gas sector [3, 9]. The structure and properties of these pipes play a key role in solving the problem of failures due to corrosion. Due to the multi-layer design, namely: the inner layer (liner) is made of polymer and provides a smooth surface, low hydraulic resistance and, most importantly, complete corrosion resistance to the transported medium; the reinforcing layer (the power frame of the pipe) consists of high-strength materials (fiberglass, polyester, aramid threads, metal tapes), which give the pipe the necessary strength and allow it to withstand high pressure; The outer layer (outer polymer shell) protects the pipe from external influences, ultraviolet radiation, groundwater, and mechanical damage [11].

1.1. Classification of Polymer Pipes in the Oil and Gas Industry

Taken together, this composite material offers a number of advantages over steel pipeline systems made of low-alloy

steels. These advantages include the following:

1) High corrosion resistance. Therefore, there is no need for additional measures to protect the pipes from corrosion;
2) High erosion resistance of the pipe interior. When extracting petroleum fluid from the reservoir, the inner surface is abraded by clay particles, sand, and mechanical impurities, but when using pipes made of non-metallic materials, wear is minimal;
3) A lower specific weight of a structure made of flexible PRP or rigid PRP compared to metal pipes;
4) Construction and installation work (C&I) time for pipes made of non-metallic materials is shorter than for the installation of similar pipes made of metals;
5) reducing the hydraulic resistance of the medium flow by reducing the roughness of the inner pipe;
6) minimizing the occurrence of undesirable factors such as scale formation, as well as the formation of asphaltene, resin, and paraffin deposits, due to reduced roughness and low thermal conductivity;
7) increasing the service life of pipelines as a whole [12-14].

PRP is currently used in the Russian Federation in the following technological operations during the production and transportation of hydrocarbon raw materials:

1) field oil pipelines – this is the most widespread application. Pipes are laid to collect well products (oil, gas, water) and transport them to processing points;
2) formation pressure maintenance systems (RPM). PRP are used to inject water into the formation to maintain pressure;
3) well flow lines. Pipes directly connect the well to the collection point, operating in the zone of the highest pressure and aggressive environment [15]. In turn, the PRP s used at oil and gas production facilities can be classified as follows: fiberglass pipes (Figure 2), rigid polymer-reinforced pipes (RPRP) (Figure 3), and flexible polymer-reinforced pipes (FPRP) (Figures 4, 5). FPRPs can in turn be divided into pipes with bonded (impregnated) and unbonded layers [16].

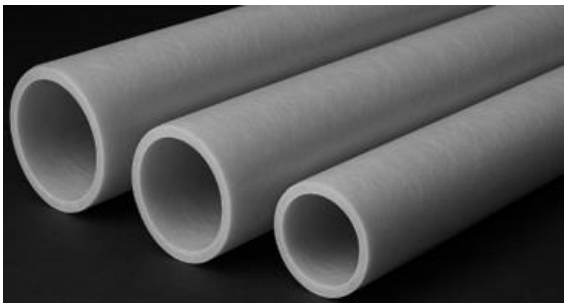


Figure 2. *Fiberglass pipes.*

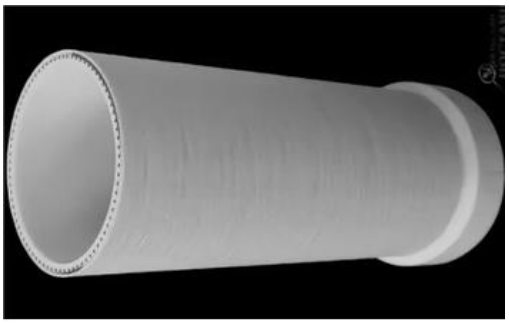


Figure 3. *RPRP of a connected structure, reinforced with metal.*

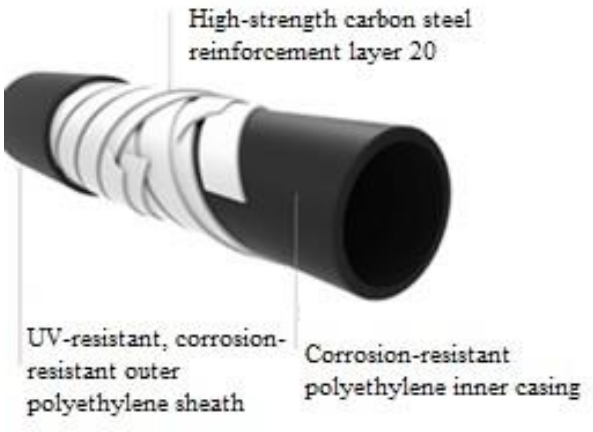


Figure 4. *Flexible polymer-reinforced pipes GPRP reinforced with metal.*

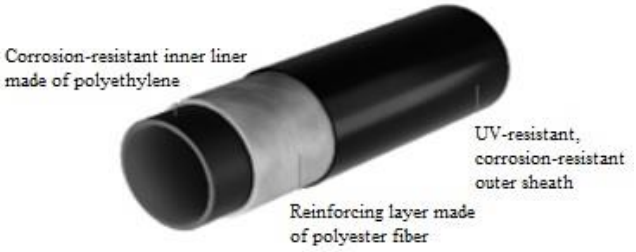


Figure 5. *Flexible polymer-reinforced pipes GPRP reinforced with fiberglass.*

1.2. Manufacturers of Polymer Pipes for the Oil and Gas Industry

Due to the high demand and commissioning of alternative pipe fittings for the oil and gas industry and other sectors, there are many companies manufacturing these products. Below is a list of the most common alternative pipe manufacturers in the Russian Federation: Nord-West LLC, Velikiye Luki; SKT-SERVIS LLC, Pskov; INTRALINE LLC, St. Petersburg; Master Vector LLC, St. Petersburg; Polimak JSC, Berezovsky; MMKT JSC (MIMIR Engineering), St. Petersburg; MEPOS LLC, Yekaterinburg; POLIPLASTIC Group LLC, Moscow; Tatneft-Presskompozit LLC, Yelabuga; Remmash-Service

LLC, Samara; KraftPipe JSC, Yelabuga; and Energomash-VTS LLC, Shchekino. At the time of writing and publication of this article, according to the authors' available data, the total length of polymer pipelines in the oil and gas industry is over 5,500 kilometers. This fact is confirmed by the introduction of polymer pipes by major oil companies such as PJSC NK Rosneft, PJSC Lukoil, PJSC Gazprom Neft, and others. These products are being implemented in the Udmurt Republic, Tomsk Oblast, Sakhalin Island, the Republic of Tatarstan, the Republic of Bashkortostan, and the Khanty-Mansi Autonomous Okrug [12, 17, 18].

1.3. Positive Experience with the Use of Pipes Made from Alternative Materials on the International Stage

In addition to domestic experience with PRP in the oil and gas industry, there are also positive examples of this product's implementation internationally. In Indonesia, a flexible composite pipe reinforced with steel wire for water with PPD is being used for underground installation. The length of this section is over 40 km, and the transported pressure is 14.5 MPa. In Tanzania, a flexible composite pipe reinforced with steel wire is used to transport high-pressure gas from a well. The pressure is approximately 14.0 MPa, and the pipeline is laid underground. In Libya, aggressive water is transported in a reservoir pressure maintenance system using, as in the previous case, a flexible polymer pipe reinforced with steel wire. In West Africa, a flexible composite pipe reinforced with synthetic fiber tape is used to transport hydrocarbon raw materials (water, gas, oil) with a system pressure of approximately 9.0 MPa. The length of this section is 9 km, the installation method is underground, and the product also crosses a reservoir with a depth of approximately 40 m. All of the above cases of using composite pipes are positive, and their introduction into the global oil and gas complex is a new sustainable trend [19-21]. Despite the great potential for using polymer-reinforced polyethylene (PRP) in the oil and gas industry, there are numerous issues related to the certification, design, and construction of pipelines. Product certification requires certification bodies whose accreditation includes test methods for checking products according to quality certificates or simulating operating conditions in laboratory conditions. Certification bodies currently test manufacturers' products in accordance with the following regulatory documents: GOST R 59834-2021; GOST R 59910-2021; P2-05.01 TTR-1214 Assessment of the technical condition and calculation of the remaining service life of polymer-reinforced pipelines. PJSC NK Rosneft; STO 1.19.3-2013 Field pipelines made of alternative materials in oil and gas producing organizations of the LUKOIL Group. It's worth noting that the current regulatory framework is of a framework nature. The aforementioned GOSTs only set general requirements. Therefore, most production companies create their own product certification documents that take into account the specifics of pipeline operation. Therefore, it is necessary to consolidate existing regulatory documents, taking into account the specifics of all consumers of these products.

The regulatory framework (GOST R 70623-2023) for the design and construction of PRP products has significant shortcomings and contains errors and inaccuracies recognized by the industry community. Work is currently underway to modernize the current regulatory documentation for both certification and the design and construction of PRP products. All of these shortcomings are related to the rapid adoption of alternative pipe materials at production and transportation facilities, as well as the high bureaucratic complexity of amending and updating current regulatory documents.

One pressing issue is the diagnosis and monitoring of PRP products in operation at oil company facilities. The existing regulatory framework allows for a highly reliable assessment of the service life of steel pipelines using methods known since the last century. At the same time, for products made of polyethylene terephthalate (PT), this issue remains open due to the complete absence of regulated control methods during operation by oil producing companies such as PAO NK Rosneft, PAO Lukoil, PAO Gazprom Neft, etc. Currently, research and development work is being conducted to test various methods for diagnosing PRP [10]. Based on the data obtained and further research and development work in this area, it will be possible to develop a diagnostic methodology for existing pipeline systems made of alternative materials, with its subsequent implementation in the state standard.

2. Conclusion

An analysis of the current state of the oil and gas industry in the Russian Federation has revealed that polymer-reinforced pipes are one of the most promising areas for pipeline development. The main advantage of polymer-reinforced pipes over traditional steel pipelines is their fundamental solution to the problem of corrosion, a factor that accounts for up to 85% of failures at fuel and energy facilities. The projected growth in the production and use of polymer-reinforced pipes indicates a high demand for this class of materials in the domestic industry. However, a systematic analysis of the regulatory framework revealed a significant contradiction. Despite the rapid growth of polymer-reinforced pipes and their increasing share in industrial pipeline systems, the methodological support for their safe operation lags significantly.

The key problems are:

1) lack of regulated diagnostic methods - unlike steel pipelines, for which proven service life assessment methods have existed since the last century, such approaches are completely lacking for polymer-reinforced pipes. - the "framework" nature of regulatory documents - current GOSTs (R 59834-2021, R 59910-2021) set only general requirements, while departmental documents of oil companies are local in nature and not standardized.

2) imperfections in the design regulatory framework - GOST R 70623-2023 contains errors and inaccuracies recognized by the industry community, necessitating updating current regulatory documents to meet the required standards.

Thus, the current situation is characterized by a critical gap between the implementation of PRP and the availability of reliable tools for monitoring their technical condition. The service life of non-metallic pipes is largely determined by the quality of work performed by contractors during installation and laying. Numerous violations often occur, which subsequently lead to premature failure, depressurization, ruptures, and environmental disasters. In order to avoid such incidents, it is necessary to improve the regulatory framework, enhance production culture, and strengthen control over construction and installation work by contractors.

Abbreviations

FEC	Fuel and Energy Complex
GDP	Gross Domestic Product
PRP	Polymer-reinforced Pipes
C&I	Construction and Installation Work
RPM	Formation Pressure Maintenance Systems
RPRP	Rigid Polymer-reinforced Pipes
FPRP	Flexible Polymer-reinforced Pipes
PT	Polyethylene Terephthalate

Author Contributions

Maxim Valeryevich Bogatov: Conceptualization, Data curation, Formal Analysis

Perov Kirill Alekseevich: Funding acquisition, Investigation, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Aleksandrova A. I., Zakrevskaya A. V., Sokolitsyn A. S. Analysis of the oil and gas sector economy in the Russian Federation. Scientific Journal of ITMO University. Series “Economics and Environmental Management”. 2019, 2, 3-14. https://doi.org/10.17586/2310-1172-2019-12-2-3-14

[2] Shaykhutdinov F. F., Guzeeva S. A. Safety of technological processes and industries in the extraction, transport and processing of hydrocarbon raw materials. New Science: Problems and Prospects. 2025, 7, 50-69. https://doi.org/10.1088/1757-899X/552/1/012042

[3] Gulin D. A., Karpova K. E., Glazkov A. S., Nasibullin T. R. On the use of polymer pipes for field pipelines. Oil and Gas Business. 2020, 18(6), 107-115. https://doi.org/10.17122/ngdelo-2020-6-107-115

[4] Zaripova L. Kh., Khafizov I. F., Spynu E. A., Khafizov F. Sh., Permyakov A. V., Ivanova Yu. S. Study of the influence of sulfate-reducing bacteria on the corrosion properties of main pipelines. Oil and Gas Business. 2022, 4, 46-68. https://doi.org/10.17122/ogbus-2022-4-46-68

[5] Okyere, M. S. (2019). Corrosion Protection for the Oil and Gas Industry: Pipelines, Subsea Equipment, and Structures (1st ed.). CRC Press. https://doi.org/10.1201/9780429056451

[6] Tyusenkov, A. S., & Nasibullina, O. A. Inhibitor anticorrosive protection of oilfield equipment. IOP Conference Series: Materials Science and Engineering. 2019, 687(6), 066021. https://doi.org/10.1088/1757-899X/687/6/066021

[7] Yudin P. E., Lozhkomoev A. S. Mechanisms of failure in anticorrosion polymer coatings on metallic surfaces of oilfield pipelines: Review. Powder Metallurgy and Functional Coatings (Izvestiya Vuzov. Poroshkovaya Metallurgiya i Funktsional'nye Pokrytiya). 2025; 19(6): 65-82. https://doi.org/10.17073/1997-308X-2025-6-65-82

[8] Polymer solutions for field pipelines // SIBUR to Customers: corporate magazine. – 2025. – March 26. – URL: https://magazine.sibur.ru/publication/direct/infrastructure/polimernye-resheniya-dlya-promyslovykh-truboprovodov/ (accessed: 06.05.2026).

[9] Berdnik M. M., Blaginina M. E., Pivnov V. P., Korobkin V. G. Research on the effectiveness of using polymer pipelines for transporting hydrocarbons using the rating assessment method. The Eurasian Scientific Journal. 2025; 17(1): https://doi.org/10.15862/14NZVN125

[10] Fedotova A. V., Salnikov A. F., Bogatov M. V., Gorshkov V. O. Evaluating the applicability of the vibroacoustic method to the determination of the residual life of pipes made of polymer reinforced materials. Diagnostics, Resource and Mechanics of materials and structures. 2026, 1, 79-95. https://doi.org/10.17804/2410-9908.2026.1.079-098

[11] Gabbasov A. I., Romanchuk A. S., Vinogradov P. V., Burkutbaev A. B., Gundorova I. G., Valiakhmetov R. I. Improving approaches to strength calculations of flexible polymer-reinforced pipes with non-metallic reinforcement. Exposition Oil Gas. 2024, 8, 122-126. https://doi.org/10.24412/2076-6785-2024-8-122-126

[12] Maksimov G. L., Promakhov V. A., Fedotova A. V., Perov K. A. Application of pipelines made of alternative materials at the fields of INK LLC. Results of application, analysis, development prospects. Engineering Practice. 2022, 3, 46-57.

[13] Aliev M. I. Design selection features of flexible polymer-reinforced pipes with unbonded layers as part of field pipelines . Oil Industry. 2025, 3, 116-120. https://doi.org/10.24887/0028-2448-2025-3-116-120

[14] Nurmakova Zh. I., Nevgod R. G., Nevgod V. V. Analysis of the use of non-metallic fiberglass pipes in Western Siberia fields. Oil and Gas Technologies and Environmental Safety. 2025, 2, 65-70. https://doi.org/10.24143/1812-9498-2025-2-65-70

[15] Yatsenko V. V., Kimlyk A. A., Kovyrshin R. V., Silin S. A., Erofeeva N. S., Ivanov V. Yu. On the prospects of using flexible polymer-reinforced pipes in gathering systems of oil fields. Oil Industry. 2025, 10, 99-101. https://doi.org/10.24887/0028-2448-2025-10-99-101

[16] Fedotova A. V., Perov K. A., Bogatov M. V. Laboratory simulation of failure mechanisms in pipes made of flexible and rigid polymer-reinforced materials and used in the oil and gas industry. Diagnostics, Resource and Mechanics of materials and structures. 2024, 6, 47-61. https://doi.org/10.17804/2410-9908.2024.6.047-061

[17] Zelenin A. A. Experience in the use of pipelines made of innovative and alternative materials at LUKOIL PJSC. Engineering Practice. 2020, 5-6.

[18] Dmitriev D. V. Ways of reusing polymer-reinforced pipelines. Engineering Practice. 2023, 7-8.

[19] Kaleni A., Magagula S. I., Motloung M. T., Mochane M. J., Mokhena T. C. Preparation and characterization of coal fly ash reinforced polymer composites: An overview. Express Polymer Letters. 2022, 16(7), 735-759. https://doi.org/10.3144/expresspolymlett.2022.54

[20] Saha A., Ramazanova A. V., Saitova A., Singha Deb A. K., Ali S. M., Banerjee T. Prospects of composite materials for the development of low-carbon energy: a review of recent advances and challenges. Journal of Materials Science: Composites. 2026, 7(1). https://doi.org/10.1186/s42252-026-00096-y

[21] Masoumi, M., Cardoso, J. L., de Carvalho Paes Loureiro, R. et al. Comparative analysis of microstructural influences on cracking in pearlitic reinforced rods steels with spheroidized vs. lamellar cementite configurations in harsh environments. Journal of Materials Science. 2025, 60, 21436-21456. https://doi.org/10.1007/s10853-025-11611-0

Biography



Maxim Valeryevich Bogatov, Research Center NEMETALL LLC (Samara, 443036, Naberezhnaya Reki Samary St., Building 1, Floor 1, Office 33, Head of the Testing, Diagnostics and Monitoring Department, Candidate of Technical Sciences, specialist in the field of research and diagnostics of polymer-reinforced pipes, Samara State Technical University, (Samara, 443100, Molodogvardeyskaya St., 244, Main Building), Associate Professor of the Department of Metal Science, Powder Metallurgy, Nanomaterials, specialist in the field of research of internal and external protective coatings used in the oil and gas industry.



Perov Kirill Alekseevich, Research Center NEMETALL LLC (Samara, 443036, Naberezhnaya Reki Samary St., Building 1, Floor 1, Office 33), Deputy Manager for Research, specialist in polymer-reinforced pipe research, in particular, deals with issues of gas permeability of various PAT structures.