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Mechanisms of state environmental supervision of the metallurgical and chemical complexes

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Abstract. The relevance of the study is determined by the significant environmental impact of Russia's metallurgical and chemical complexes, which are key industrial sectors and major sources of pollution. The tightening of environmental legislation and the introduction of new oversight tools necessitate a comprehensive research of their effectiveness. The study aims to analyze the system of state environmental supervision over these sectors and assess practical measures to reduce their negative environmental impact. The study is based on a systematic approach and an analysis of the regulatory framework, including federal legislation, by-laws (such as Government Decree No 1096), and industry strategies. The methods of comparative analysis of supervisory practices in the two sectors, examination of statistical data from the Russian Ministry of Natural Resources, case studies of specific enterprises (PJSC "Norilsk Nickel", PJSC "MMK"), and generalization of materials from scientific publications and official reports were used. Results. The structure and key mechanisms of federal environmental oversight, carried out by Federal Service for Supervision of Natural Resources, are identified: risk-based inspections, automated emission monitoring, integrated environmental permits (IEP), and strict liability for violations. It is shown that a combination of administrative measures (fines, suspension of operations), economic incentives (subsidies for best available technologies (BAT) implementation), and corporate initiatives lead to environmental modernization. It was found that, despite common tools, supervision has industry-specific features: in metallurgy, the focus is on emission reduction under the national "Clean Air" project, while in the chemical complex, it is on building a chemical safety system and remediating legacy pollution. It is concluded that state regulation has entered a phase of eco-oriented transformation, where supervision acts as a driver of modernization. However, challenges remain, related to the wear and tear of assets and the need for large investments. Promising avenues for further research include the study of regional aspects of supervision, assessing the economic efficiency of BAT implementation for individual enterprises, and studying the adaptation of industries to new climate requirements, including cross-border carbon regulation (CBAM).

Keywords: environmental protection control, internal audit, non-ferrous metallurgy, oil and gas petrochemical industry, integrated environmental permit, available methodologies, industrial monitoring, anthropogenic impact, technogenic safety

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Механизмы государственного экологического надзора металлургического и химического комплексов

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Аннотация. Актуальность исследования обусловлена высокой экологической нагрузкой со стороны металлургического и химического комплексов России, являющихся ключевыми отраслями промышленности и одновременно крупными источниками загрязнения. Ужесточение экологического законодательства и внедрение новых инструментов государственного экологического надзора требуют комплексного изучения их эффективности и оценки практических мер по снижению негативного воздействия металлургического и химического комплексов на окружающую среду. В основе исследования лежит системный подход и анализ нормативно-правовой базы, включая федеральное законодательство, подзаконные акты (такие как Постановление Правительства № 1096) и отраслевые стратегии. Использованы методы сравнительного анализа надзорной практики в двух отраслях, изучения статистических данных Минприроды России и кейсы конкретных предприятий (ПАО «Норильский никель», ПАО «ММК»), а также обобщения материалов научных публикаций и официальных отчетов. Выявлены структура и ключевые механизмы федерального экологического надзора, осуществляемого Росприроднадзором: риск-ориентированные проверки, автоматизированный мониторинг выбросов, комплексные экологические разрешения (КЭР) и строгая ответственность за нарушения. Показано, что сочетание административных мер (штрафы, приостановка деятельности), экономических стимулов (субсидии на наилучшие доступные технологии (НДТ)) и корпоративных инициатив ведет к экологической модернизации. Установлено, что, несмотря на общие инструменты, надзор имеет отраслевую специфику: в металлургии фокус смещен на снижение выбросов в рамках нацпроекта «Чистый воздух», а в химическом комплексе — на создание системы химической безопасности и ликвидацию накопленного вреда. Сделан вывод о том, что государственное регулирование вступило в фазу эколого-ориентированной трансформации, где надзор выступает драйвером модернизации. Однако сохраняются проблемы, связанные с износом фондов и необходимостью крупных инвестиций. Перспективными направлениями дальнейших исследований видятся изучение региональных аспектов надзора, оценка экономической эффективности внедрения НДТ для отдельных предприятий, а также изучение адаптации отраслей к новым климатическим требованиям, включая трансграничное углеродное регулирование (СВАМ).

Ключевые слова: природоохранный контроль, внутренний аудит, цветная металлургия, нефтегазохимия, интегрированное разрешение, доступные методики, производственный мониторинг, антропогенное воздействие, техногенная безопасность.

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Introduction

The effectiveness of environmental regulation is largely determined by the effectiveness of control and supervision mechanisms. Even the strictest regulatory framework requires proper enforcement, which is ensured by the system of state environmental supervision [1]. The relevance of the research topic is due to the fact that the metallurgical and chemical sectors, which are the locomotives of Russian industry, simultaneously represent the largest sources of complex environmental pollution. For instance, consuming 25% of all water used by Russian industry, metallurgical enterprises often discharge insufficiently treated wastewater, leading to direct contamination of groundwater [2]. The intensification of supervisory activities, the introduction of new regulatory instruments, and the tightening of liability require a comprehensive analysis of their effectiveness and the identification of bottlenecks.

The novelty of our research lies in a comprehensive and comparative analysis of modern state environmental supervision mechanisms as applied to two key industrial complexes — metallurgical and chemical — considering their sectoral specificities. The focus is on the latest legislative changes (such as the “Usolye Law”), the practice of implementing integrated environmental permits and best available techniques, as well as the results of implementing large-scale national projects (“Clean Air”, “Clean Country”), systematized in the context of supervisory activities.

The aim of the study is to analyze the state environmental supervision system in the metallurgical and chemical industries of Russia and to evaluate the practical measures taken to reduce the environmental burden.

To achieve this aim, the following tasks are set:

- to reveal the structure and characterize the key instruments of federal state environmental supervision (risk-based inspections, monitoring, permitting system);
- to analyze the practice of applying supervisory measures and legal liability using specific incidents and programs as examples;
- to identify sectoral features of environmental modernization and adaptation to tightening norms in the metallurgical complex (implementation of best available technologies (BAT), emission reduction);
- to investigate the specifics of regulation and ensuring chemical safety at chemical complex enterprises, including waste management and remediation of accumulated damage.

Methodology

To achieve the aim and solve the tasks set in research, a set of general scientific and specific scientific methods was applied, and appropriate information sources were identified.

The main research method is the systems approach, which allows considering state environmental supervision as an integral system interacting with legal, economic, and technological subsystems, and identifying the interconnections between its elements (regulatory framework, control measures, liability measures).

To compare the supervision mechanisms and the specifics of their application in the metallurgical and chemical industries, comparative legal analysis was used.

For an in-depth study of practical cases of implementing supervisory measures, such as prosecuting Norilsk Nickel PJSC, the modernization experience of Magnitogorsk Iron and Steel Works PJSC and NLMK PJSC, as well as the remediation of accumulated damage sites within the “Clean Country” project, the case-study method was applied.

To work with official reports and statistical data from the Ministry of Natural Resources of Russia and Federal Service for Supervision of Natural Resources, materials from national projects (“Clean Air”), public corporate reports, and scientific publications in peer-reviewed journals on the research topic, the method of document and secondary data analysis was used.

The source base of the research includes legislation of the Russian Federation, decisions of the Eurasian Economic Commission, official reports of state bodies, strategic and conceptual documents (Concept for the Management of Chemical Substances, sectoral development strategies), as well as scientific monographs and articles on environmental problems and industrial regulation.

Results

The state environmental supervision system is a set of measures to monitor compliance with environmental legislation and enforce its implementation¹. In the Russian Federation, the functions of federal state environmental supervision are entrusted to the Federal Service for Supervision of Natural Resources (Rosprirodnadzor). The procedure for exercising supervision is established by Decree of the Government of the Russian Federation No. 1096 of June 30, 2021, “On Federal State Environmental Control (Supervision)”². According to this

¹ On Amendments to Certain Legislative Acts of the Russian Federation on the implementation of State control (supervision) and Municipal control: Federal Law No. 242-FZ of 07.18.2011. *Collection of Legislation of the Russian Federation*. 2011;30 (Part I). Art. 4590. (In Russ.).

² On Federal State Environmental Control (Supervision): Decree of the Government of the Russian Federation No. 1096 dated 30.06.2021. *Collection of legislation of the Russian Federation*. 2021;27. Art. 5462. (In Russ.).

provision, Rosprirodnadzor conducts scheduled and unscheduled inspections of enterprises classified as objects of federal supervision (typically the largest polluters of Category I, including many metallurgical and chemical plants). Control is carried out based on a risk-oriented approach; the frequency of inspections depends on the risk category of the object [3]. During inspections, supervisory inspectors check compliance with mandatory environmental requirements, such as the availability of necessary permitting documentation (integrated permit for Category I objects, emission and discharge permits for Category II objects, etc.), compliance of actual emissions with established standards, adherence to waste management rules, and execution of previously issued orders. Increased attention is paid to enterprises located in cities with high levels of air pollution, as well as to large production complexes with continuous cycles (metallurgical plants, full-cycle petrochemical and chemical plants).

Supervisory activity instruments are constantly being improved. Digital monitoring is being introduced. For instance, a number of Category I enterprises are required to install automatic emission and discharge control systems, data from which is transmitted in real-time to Rosprirodnadzor. This allows for prompt detection of standard exceedances. Simultaneously, the state environmental monitoring system operates, tracking air, water, and soil quality near industrial zones, serving as an indirect indicator of the impact of enterprises and the effectiveness of environmental protection measures. Based on monitoring and inspection data, supervisory authorities issue binding orders to enterprises to eliminate identified violations (e.g., reduce emissions to standard levels, upgrade treatment equipment, remediate disturbed lands, etc.). Failure to comply with orders entails sanctions — from large fines to suspension of the enterprise's activities by court order.

For violating environmental requirements, legal liability measures are applied to the guilty parties. Administrative liability for officials and legal entities is provided for by the Code of the Russian Federation on Administrative Offences; fines for exceeding emission standards, lack of permits, violation of hazardous waste management rules can reach hundreds of thousands and millions of rubles. For example, non-compliance with the terms of an integrated environmental permit incurs fines of up to 200 thousand rubles or suspension of activities. Criminal liability occurs if the act causes significant harm to the environment or human health. The Criminal Code of the Russian Federation contains a chapter on environmental crimes, which provides for sanctions up to imprisonment for serious pollution of the natural environment. In the last 5–10 years the precedents have emerged in Rosprirodnadzor's practice for prosecuting large companies. The case with Norilsk Nickel PJSC is illustrative. For the large-scale environmental pollution resulting from an emergency diesel fuel spill in 2020, the enterprise was fined a record amount of 146 billion rubles, and these funds were collected through

the court to compensate for damage to Arctic ecosystems³. This unprecedented fine confirmed the principle of full compensation for harm and served as a signal to industry about the inadmissibility of neglecting environmental safety.

A significant strengthening of the supervisory regime occurred with the entry into force on September 1, 2023, of the so-called “Usolye Law” — Federal Law No. 446-FZ of December 30, 2021, adopted after a series of environmental problems at decommissioned enterprises. The “Usolye Law” obliged owners of hazardous production facilities of hazard classes I and II to register with the Ministry of Natural Resources of Russia well in advance (5 years before the planned decommissioning of the facility), disclose data about their facility, and develop a liquidation and remediation project⁴. Upon closing an enterprise, the owner is obliged to fully eliminate the accumulated environmental damage at their own expense. An owner who fails to comply with the requirements must pay a special compensatory environmental fee, and until it is paid, dividend payments to shareholders are prohibited. The innovations are aimed at preventing the emergence of “abandoned” contaminated industrial sites and enshrine the principle that remediation of harm is the responsibility of business, not the state. The law’s requirements were accompanied by an inventory — enterprises were ordered to provide information about their potentially toxic objects by March 2025, including their service life and decommissioning plans. Although in practice not all have promptly fulfilled these orders, the authorities demonstrate determination to see it through, applying sanctions to violators if necessary⁵.

The effectiveness of state supervision largely depends on the inevitability of punishment and regularity of control. Rosprirodnadzor has received the right in some cases to suspend the activities of enterprises without a court decision (for example, in the event of an immediate threat to human life and health); unscheduled inspections based on signals of violations are used more widely. Data on large industrial enterprises (presence of integrated environmental permits (IEP), cases of exceeding standards, application of BAT) become publicly available on special portals, allowing the public and environmental organizations to exercise public control and increase pressure on violators

³ *The decision of the Arbitration Court of the Krasnoyarsk Territory dated 2021 on the claim of Rosprirodnadzor against PJSC Norilsk Nickel for damages in the amount of 146 billion rubles for a diesel fuel spill in the Norilsk taiga.* (In Russ.).

⁴ On Amendments to the Federal Law “On Environmental Protection” and Certain Legislative Acts of the Russian Federation: Federal Law No. 446-FZ dated 12.30.2021. *Collection of legislation of the Russian Federation*. 2022;1 (part I). Art. 15. (In Russ.).

⁵ Considering the environmental friendliness of production facilities: the rates of payment for negative environmental impact for 2026–2030 have been approved: press release dated 09.05.2025. *Ministry of Natural Resources of Russia*. URL: https://www.mnr.gov.ru/press/news/s_uchyeto_ekologichnosti_proizvodstv_utverzhdenny_stavki_platy_za_negativnoe_vozdeystvie_na_okruzhayuyu/?sphrase_id=1256769 (accessed: 10.10.2025). (In Russ.).

through reputational methods. As a result, the environmental transparency of the companies themselves is gradually increasing. The implementation of BAT, as world experience shows, not only reduces emissions but also improves production culture, as enterprises are forced to keep records and control of their impacts and report on the results, which contributes to the growth of management's environmental responsibility.

Summing up, it can be noted that an integrated system of environmental supervision is emerging in Russia, combining administrative levers (inspections, orders, fines), economic incentives (benefits for environmentally friendly enterprises, high payments for polluters), and organizational measures (monitoring, registration of objects, information transparency). The state consistently improves environmental legislation, making it clearer and more transparent for all economic actors, and environmental well-being is proclaimed one of the national development goals⁶. Next, we will consider how these supervisory mechanisms are implemented in practice in relation to the metallurgical and chemical complexes, taking into account their specificities.

The metallurgical industry is one of the basic sectors of the Russian economy and simultaneously one of the largest sources of man-made impact on nature⁷. Ferrous and non-ferrous metallurgy enterprises have historically determined a high level of environmental pollution in industrial regions (mass emissions of dust, sulfur dioxide, nitrogen oxides, carbon monoxide, heavy metals, etc.) [4]. Such environmental burden requires special regulatory and supervisory measures. The state has been tightening environmental requirements for the metallurgical complex, stimulating it towards deep technological modernization. This course is clearly outlined at the highest level. President V.V. Putin stated in 2024 the need for a major overhaul of metallurgical production facilities, taking into account environmental safety issues, emphasizing that strict compliance with environmental standards is critically important for the country⁸. Within the framework of the national project "Clean Air"⁹, the largest metallurgical centers (Norilsk, Chelyabinsk, Magnitogorsk, Nizhny Tagil, etc.) are implementing programs for the phased

⁶Considering the environmental friendliness of production facilities: the rates of payment for negative environmental impact for 2026–2030 have been approved: press release dated 09.05.2025. Ministry of Natural Resources of Russia. URL: https://www.mnr.gov.ru/press/news/s_uchyetom_ekologichnosti_proizvodstv_utverzhdeny_stavki_platy_za_negativnoe_vozdeystvie_na_okruzhayu/?sphrase_id=1256769 (accessed: 10.10.2025). (In Russ.).

⁷Rogozhnikov DA, Shoppert AA, Loginova IV. *Ecological problems of metallurgical production : textbook. stipend*. Yekaterinburg: Publishing house of UMTS UPI; 2017. (In Russ.).

⁸Opening of metallurgical industry facilities in the regions: transcript of the speech of the President of the Russian Federation. URL: <http://www.kremlin.ru/events/president/transcripts/copy/74560> (accessed: 10.10.2025). (In Russ.).

⁹Passport of the Federal project "Clean Air": appendix to the minutes of the meeting of the project Committee for the national project "Ecology" No. 3 dated 12.21.2018. URL: <https://base.garant.ru/401533498/> (accessed: 10.10.2025). (In Russ.).

reduction of pollutant emissions. By 2030, the total volume of emissions in the 12 most polluted industrial cities should decrease by 50% from the 2017 level. To achieve this goal, enterprises are introducing modern gas cleaning systems, transitioning from outdated production processes (e.g., open-hearth furnaces) to more environmentally friendly converter and electric melting technologies, and increasing the share of secondary metallurgy (scrap recycling) in output. These measures significantly reduce the burden on the environment by reducing the volume of ore processing and associated emissions.

The widespread transition to best available techniques has become a key instrument for environmental modernization of metallurgy. Almost all large metallurgical plants are classified as Category I objects, and as noted above, they were obliged to obtain integrated environmental permits by January 1, 2025. According to official data from the Ministry of Natural Resources, as of early 2025, 3,514 organizations nationwide had already received such permits, while about 887 Category I enterprises (from various industries) had not yet fulfilled this requirement and had not confirmed compliance with their sectoral BATs. Among the laggards are some older metallurgical plants that require time and investment for modernization. Nevertheless, enterprises that fail to switch to new standards in time face restrictions and increased fines, up to the risk of suspension of activities. The presence of an integrated environmental permit means that the plant has implemented or is implementing BAT for all major environmental aspects — from flue gas and wastewater treatment to safe waste management and emission monitoring. For large metallurgical plants, based on BAT reference documents, technological standards have been developed for dust capture in sinter plants, deep purification of sulfur-containing gases (achieving the production of elemental sulfur instead of SO₂ emissions into the atmosphere), closed water circulation, and other areas. Some enterprises have already reported significant results. For instance, Magnitogorsk Iron and Steel Works PJSC announced a 20% reduction in dust emissions after modernizing its sintering plant, and NLMK PJSC converted several blast furnaces to natural gas injection technology, which reduced the formation of carbon dioxide and nitrogen oxides¹⁰. Although these results require independent verification, the trend is obvious — environmental performance is becoming part of the competitiveness of metallurgical companies [5], especially considering the emergence of external requirements (e.g., the introduction of the EU's Cross-Border Carbon Adjustment Mechanism (CBAM) on metal products¹¹).

The state, for its part, supports the environmental modernization of metallurgy through various programs and benefits. Since 2019, a mechanism for supporting BAT

¹⁰ *Data from the annual environmental reports of PJSC Magnitogorsk Iron and Steel Works and PJSC NLMK for 2023–2024.* (In Russ.).

¹¹ *The mechanism of Cross-border Carbon Regulation (CBAM).* URL: <https://www.metalsmining.ru/ru/green/1970-cbam.html> (accessed: 10.10.2025). (In Russ.).

and improving environmental efficiency has been in place, under which enterprises implementing comprehensive investment projects to introduce BAT can receive preferential loans, interest rate subsidies, and benefit from accelerated depreciation of new equipment¹². Some metallurgical companies have taken advantage of these opportunities during capacity reconstruction. Furthermore, the state encourages the use of secondary resources and has set requirements for increasing the share of scrap metal in steel production; the creation of infrastructure for collecting and processing waste from metallurgical production (dump slags, gas cleaning sludges, spent furnace linings, etc.) for their re-involvement in economic circulation is stimulated. This not only reduces the volume of waste destined for disposal but also reduces the extraction of primary raw materials, thereby reducing the total impact on nature.

Separately, efforts to reduce the risk of environmental accidents at metallurgical enterprises should be noted. After several major incidents (e.g., emergency emissions in Norilsk in 2020, etc.), industrial and environmental safety requirements were strengthened [6]. For metallurgical facilities with hydraulic structures (sludge reservoirs, settling ponds), mandatory emergency response plans considering environmental consequences have been introduced, which are checked by Rostekhnadzor. These measures are aimed at preventing major man-made disasters and minimizing damage if an emergency does occur [7].

The chemical and petrochemical complex poses particular challenges for environmental regulation, related to the diversity of substances produced, their potential toxicity, and the long-life cycle of chemical products (from production to disposal). Historically, regulation in the field of chemical substances management in Russia was fragmentary, and different aspects were enshrined in separate acts (sanitary norms, rules for transporting dangerous goods, standards for the content of harmful substances in products and emissions), but an integrated system of state control over the full life cycle of chemical products was absent. The “Concept for the Development of the State Regulation System for the Management of Chemical Substances and Products”¹³ directly noted that at that time, state regulation in this area was fragmented and did not provide a systematic approach to responding

¹² On Approval of the Rules for Granting Subsidies from the Federal Budget to Russian Organizations for Reimbursement of part of the cost of Paying coupon Income on Bonds Issued as part of Investment Projects to introduce the best Available Technologies, and (or) for reimbursement of part of the cost of Paying interest on loans Received from Russian credit organizations, the State Development Corporation “WEB. Russian Federation”, as well as in international financial organizations established in accordance with international treaties in which the Russian Federation participates, for the implementation of investment projects on the introduction of the best available technologies : Decree of the Government of the Russian Federation No. 541 dated 30.04.2019. *Collection of Legislation of the Russian Federation*. 2019;19. Art. 2298. (In Russ.).

¹³ On Approval of the Concept for the Development of the State Regulation System for the Management of Chemical Substances and Products: Order of the Ministry of Industry and Trade of the Russian Federation No. 4372 of December 31, 2015. URL: <https://base.garant.ru/72051618/> (accessed: 10.10.2025).

to the problems of chemical substances management. Key problems identified included: the absence of a unified register of all chemical substances and mixtures in circulation; insufficient data collection on production volumes, imports, and use of chemical substances; the absence of procedures for assessing the risks of substance impact on health and nature for making decisions on banning or restricting their use; the closed nature of information on the hazardous properties of substances and the absence of a publicly accessible register; weak public involvement in discussing chemical safety issues. To address these gaps, the 2015 Concept outlined the creation of an integrated management system for chemical substances, including a national register of chemical substances and mixtures, a mechanism for notifying new chemical substances before they are placed on the market, conducting phased risk assessment to prioritize measures, and ensuring wide accessibility of information on the properties and hazards of substances.

Over the past decade, several provisions of this Concept have begun to be implemented. A key step was, as already mentioned, the adoption of the unified EAEU technical regulation “On the Safety of Chemical Products”, which entered into force in June 2021¹⁴. This technical regulation introduced the requirement for mandatory state registration of all chemical substances placed on the market. A unified EAEU register with basic information is being formed for substances already on the market, while new substances must undergo a notification procedure (prior notification and assessment) before their industrial production or import in significant quantities. The technical regulation also establishes uniform rules for classifying the hazards of substances (based on the GHS) and requirements for safety data sheets for each hazardous chemical substance, which producers must provide to consumers throughout the supply chain. The implementation of these measures allows authorities to obtain reliable information on circulating chemical substances, their hazardous properties, and volumes of use, which was previously difficult due to fragmented record-keeping. As experts note, with the entry into force of the technical regulation, national legislation has enshrined internationally recognized approaches to hazard assessment and chemical product information, creating prerequisites for the development of regulation in related areas — for example, control of climate-active substances and emerging pollutants [8]. The harmonization of chemical safety regulation with global standards is taking place, which is particularly important for the integration of the Russian chemical industry into global markets (considering the export of chemical products and foreign partners’ requirements for the environmental cleanliness of goods).

State environmental control at chemical complex enterprises is largely similar to that in metallurgy — the same mechanisms of integrated permits,

¹⁴ *On the Technical Regulations of the Eurasian Economic Union “On the safety of chemical products”*: Decision of the Council of the Eurasian Economic Commission No. 19 dated 03.03.2017. URL: <https://docs.eaeunion.org> (accessed: 10.10.2025). (In Russ.).

supervisory inspections, and monitoring are applied. Many large chemical plants are also classified as Category I objects and have received or must receive IEPs, implementing BAT¹⁵. For the chemical industry, the transition to BAT means the application of modern technologies for cleaning emissions of volatile organic compounds (e.g., solvent vapor recovery, flare incineration and catalytic neutralization of exhaust gases), the introduction of zero-waste or low-tonnage process schemes, closed water circulation systems, and the reuse of by-products. The development of BAT reference documents for chemical production was one of the most challenging tasks due to the diversity of processes — from mineral fertilizer production to plastics and organic synthesis. Nevertheless, by 2017–2019, reference documents for the main areas of the chemical industry were prepared, and now newly designed chemical production facilities must comply with their recommendations. This is also reflected in the industry development strategy, as the state is focused on improving the environmental friendliness and energy efficiency of chemical production as a necessary condition for competitiveness in the global market¹⁶.

One of the acute issues for the chemical complex is waste management and the remediation of accumulated damage from past years. Chemical enterprises, especially those operating since the Soviet period, have often left behind contaminated territories, sludge reservoirs, and toxic waste landfills (e.g., dumps from mercury production, tar ponds from petrochemicals, etc.) [9]. Within the framework of the federal project “Clean Country” (national project “Ecology”), work is underway to remediate accumulated damage sites, many of which are associated with the chemical complex. An example is the ongoing remediation of the “Krasny Bor” landfill in the Leningrad Region, where hazardous chemical waste was stored for many years. Concurrently, with the adoption of the “Usolye Law”, requirements for the enterprises themselves have been tightened. Now owners of chemically hazardous production facilities are obliged, after closing plants, to clean and neutralize contaminated sites at their own expense¹⁷. Control over this process is carried out by Rosprirodnadzor, which issues a conclusion on the completeness of the implemented liquidation measures; only with such a conclusion is the object

¹⁵ On approval of payment rates for negative environmental impact in 2026–2030: Decree of the Government of the Russian Federation No. 2409-r dated 09.01.2025. *Collection of Legislation of the Russian Federation*. 2025;36. Art. 5378. (In Russ.).

¹⁶ On approval of the Strategy for the Development of the Chemical and Petrochemical complex for the period up to 2030: Order of the Ministry of Industry and Trade of the Russian Federation and the Ministry of Energy of the Russian Federation No. 651/172 dated 08.04.2014. URL: <https://base.garant.ru/70851478/> (accessed: 10.10.2025). (In Russ.).

¹⁷ On Amendments to the Federal Law “On Environmental Protection” and Certain Legislative Acts of the Russian Federation: Federal Law No. 446-FZ dated 12.30.2021. *Collection of Legislation of the Russian Federation*. 2022;1 (Part I). Art. 15. (In Russ.).

considered removed from supervision. The new requirements stimulate companies to take a more responsible approach to the safe decommissioning of production facilities and to plan environmental costs in advance.

An important part of ensuring environmental safety in the chemical complex is preventing accidents with the release of hazardous substances. Here, environmental regulation intersects with industrial safety requirements. Enterprises of hazard classes I and II are obliged to develop industrial safety declarations and emergency response plans and coordinate them with the Ministry of Emergency Situations and regional authorities. After several man-made accidents at chemical facilities (explosion at the Azot plant in Berezniki in 2018, fire at a petrochemical plant in Ufa in 2016, etc.), requirements for such plans were strengthened. The practice of regular drills and exercises for localizing chemical accidents at the most hazardous enterprises has also been introduced — this is monitored by the Ministry of Emergency Situations and Rostekhnadzor. In the event of an accident-causing environmental damage, the same legal mechanisms for harm compensation and prosecution of the guilty, described earlier (through judicial and administrative procedures), are applied.

It should be noted that the chemical complex has been actively integrating into the implementation of the circular economic tasks in recent years. The state stimulates chemical enterprises to find ways to turn waste into secondary raw materials — quotas and standards for the use of secondary resources in the production of chemical products have been introduced, and infrastructure for collecting and processing used chemical products (car tires, plastics, batteries, etc.) is being developed. In 2018, the Government of the Russian Federation approved the “Strategy for the Development of the Processing, Recycling, and Neutralization of Waste Industry for the Period up to 2030”¹⁸, which sets guidelines for the formation of a new waste processing industry, with a significant role assigned to metallurgical and chemical waste. Among the tasks are increasing the share of recycled industrial waste to 50%, creating clusters for processing metallurgical and chemical waste, and developing technologies for neutralizing highly toxic waste. The implementation of this strategy should reduce the environmental burden of waste storage and ensure the return of valuable materials (polymers, rubber, reagents) back into the production cycle. For chemical industry enterprises, this means the emergence of new requirements — mandatory sorting of their waste, transferring it to specialized processors, implementing best available techniques for neutralizing hazardous residues. The state is gradually forming the regulatory framework for these processes and providing financial incentives.

¹⁸ On approval of the Industrial Development Strategy for the processing, disposal and neutralization of industrial and consumer waste for the period up to 2030: Decree of the Government of the Russian Federation No. 84-r dated 25.01.2018. *Collection of Legislation of the Russian Federation*. 2018;6. Art. 920. (In Russ.).

As a result, the regulatory system for the chemical complex is currently undergoing a phase of active development and renewal. From initially fragmented norms, it is moving towards an integrated chemical safety system covering the full cycle: substance registration — risk assessment — prevention — control — information. Russian regulation is increasingly taking into account international experience, whether European (REACH regulations, industrial emissions directives) or global (GHS, relevant conventions). It is important that large companies in the chemical sector have also begun to perceive ecology as a priority. Many companies are implementing environmental management systems according to the ISO 14001 standard, publishing environmental reports, reducing greenhouse gas emissions, and switching to “green” technologies within their corporate sustainable development strategies. Of course, the driving force behind these changes is largely the pressure from the state and the market — only under the threat of sanctions or loss of sales markets do companies make significant environmental investments. The introduction of the EU’s Cross-Border Carbon Adjustment Mechanism has stimulated a number of Russian fertilizer and organic chemical producers to think about reducing CO₂ and nitrous oxide emissions to keep their products competitive. In this direction, state actions (adoption of a law on reducing greenhouse gas emissions, launching a carbon credit trading system in the Sakhalin Region as a pilot project, etc.) complement environmental regulation, establishing a new level of requirements — climatic — for both the chemical and metallurgical industries. Consequently, environmental regulation is expanding horizontally (covering ever new aspects — from traditional pollution to climate factors) and vertically (increasing the strictness and detail of norms).

Conclusion

Thus, state regulation of environmental aspects of the metallurgical and chemical complexes in Russia has entered a phase of environmentally oriented transformation. In September 2025, a government decree was adopted on payment rates for negative environmental impact for 2026–2030¹⁹. Strict supervision, the mandatory transition to best available techniques and integrated permits are effectively changing the technological base of industry, making it more environmentally friendly. A reduction in negative impact on nature is already being observed; in several industrial centers, pollutant emissions are decreasing, the state of the environment is improving, and risks to public health are diminishing. At the same time, the “greening” of industry increases its efficiency and competitiveness. Resource- and energy-saving technologies allow enterprises to save money, and

¹⁹ On approval of payment rates for negative environmental impact in 2026–2030 : Decree of the Government of the Russian Federation No. 2409-r dated 09.01.2025. *Collection of Legislation of the Russian Federation*. 2025;36. Art. 5378. (In Russ.).

compliance with international environmental standards opens access to new markets and investments. Environmental regulation is turning from a brake into a driver for the modernization of metallurgical and chemical complexes.

Many plants still operate worn-out fixed assets requiring large-scale upgrades, which not all companies are willing to undertake under economic constraints. Supervisory practice shows that some enterprises try to circumvent strict requirements or postpone environmental projects. Therefore, the state is strengthening control, increasing the inevitability of punishment for violations, and simultaneously improving the regulatory framework, eliminating gaps and excessive requirements. The support of the country's top leadership for the environmental agenda (e.g., including environmental well-being indicators in national development goals, presidential directives on increasing the environmental responsibility of business) sets the tone for the entire management vertical.

In the future, further tightening of environmental standards appears inevitable. The key task is to maintain a balance between industrial development and nature protection in the interests of current and future generations. Russian experience shows that with political will and a systematic approach, the state is capable of directing large industries towards the path of environmentally responsible development. This serves as a foundation for the country's long-term environmental safety and its sustainable development.

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