HEALTH RISK MANAGEMENT AS AN INNOVATIVE MECHANISM FOR ENSURING OIL REFINERIES ARE SAFE FOR THE LOCAL POPULATION

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Abstract

The research is aimed at developing and approbation of decision-making algorithm to ensure environmental safety of oil refining areas for local population based on the mechanism of health risk assessment. Its implementation at all stages of the life cycle of environmentally hazardous production facilities ensures compliance with the regulatory level of environmental impacts on the border of the enterprise sanitary protection zone and the adjacent residential areas.

Methodologically, the research is based on conceptual provisions of the risk management theory and corresponding standards of ISO 31000 series, which prescribe regulated risk management procedures: risk identification (by risk hazards and their sources); risk assessment and their prioritization by degree of significance; planning and implementation of risk management tools; monitoring residual risks. Risk assessment was performed using the standard Russian health risk assessment methodology.

The algorithm is a set of sequential procedures for making decisions to ensure the residual health risk meets regulatory requirements. Emphasis is placed on the stages of design and operation of an environmentally hazardous facility when the level of health risks posed is particularly sensitive to the results of the decisions made. Timely identification of hazards and assessment of health risks allows to define the location of environmentally hazardous facilities at the design, considering their risk-posing capacity. During operation stage, the riskiest areas of the sanitary protection zone boundary and the industrial site, priority facilities and chemical toxicants (in terms of created risks) are identified. This provides a basis for adjusting the industrial and environmental control programs, prioritizing investment programs and plans of environmental protection (considering the expected reduction of the health risk), as well as operational documentation (to minimize the possibility of creating high risk emissions). Risk management tools are used - risk avoidance, reducing the severity of consequences, reducing the probability of risks.

The algorithm makes it possible to ensure meeting the regulatory requirements for residual health risk during the operation of environmentally hazardous oil refinery facility, while avoiding significant financial costs because of environmentally insufficient planning and technological decisions made. The algorithm can be used for the operating industrial facilities and new construction objects, regardless of the industry specifics. It is applicable to chemical pollution of atmospheric air, acoustic and electromagnetic influence, pollution of water.

Keywords: risk management; health risk assessment; chemical air pollution; regulatory level of residual health risk; priority risk-posing oil refineries, priority risk-posing chemical toxicants

I. Introduction

In today's world, wealth creation is accompanied by increasing risks [1], and billions of people are confused and anxious when they think about what is happening, as habits and traditions of economic management are rapidly losing effectiveness. The significant increase in the role of anthropogenic and natural risks in recent years [2-4] changes the traditional understanding of sustainable development[1] towards considering it as the ability of individuals, communities and geosystems[2] to survive in the face of disasters and long-term negative impacts. This vision of sustainability is particularly relevant when it comes to populations in regions with highly developed industries, especially mining, oil refining, petrochemical, metallurgical, fertilizer and heat production industries. The size of the negative consequences and damage to health from the impact of industrial emissions on vital organs, at first glance, cannot be compared with the situations of major human-made accidents and disasters. Nevertheless, the available ecological and economic calculations prove it is rather high, almost comparable [5].

The burden of disease associated with air pollution is now on a par with other major global health risk factors, such as tobacco smoking. According to the WHO, each year exposure to air pollution causes 7 million premature deaths and the loss of millions of healthy years of life. Up to 30% of deaths from leading non-communicable diseases (strokes, lung cancer and chronic obstructive pulmonary disease) and 25% of deaths from heart attacks are linked to air pollution, with adverse health effects most pronounced among women, children, the elderly and the poor [6]. Back in 2013, the IARC[3] classified outdoor air pollution as carcinogenic to humans (group 1). The increasing risk of lung cancer with increasing air pollution has been confirmed[4].

According to Russian legislation, compliance with regulatory environmental requirements is established as one of the mandatory conditions for the operation of an industrial enterprise, which implements the constitutional right of citizens to a favorable environment. Particularly strict requirements are imposed on environmentally hazardous facilities[5], which include oil refineries - when commissioning new and (or) reconstructing existing facilities, as well as during their operation, along with ensuring non-exceeding technological emission standards and (or) maximum allowable emissions (in accordance with current legislation), responsibility is established for ensuring an acceptable level of health risk on the border of the sanitary protection zone. This regulatory context creates new challenges for the board, the management, and the line personnel of the refinery. Responsibility for the environmental well-being of the population of adjacent areas makes it necessary to consider and assess its environmental impacts and the measures taken to reduce such impacts in the broad context of risk-based management. It puts the task of reducing health risks among the priorities of effective corporate management, in accordance with the ESG principles of environmental and social responsibility.

In the risk-oriented logic, ensuring the environmental safety of the population means that the actual value of the health risk created by industrial emissions at the sanitary protection zone

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[1] On October 20, 1987, the Plenary Session of the UN General Assembly adopted a resolution defining the basic principle of sustainable development as defined by the Brundtland Commission: "It is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

[2] A geosystem is a relatively integral area developed in close interconnection and interaction of nature, population and economy, the integrity of which is determined by direct, reverse and transformed links between geosystem subsystems.

[3] International Agency for Research on Cancer (IARC), part of the UN World Health Organization

[4] https://www.iarc.who.int/wp-content/uploads/2020/12/pr292_E.pdf

[5] I and II categories of hazard (Chapter VII SanPiN 2.2.1/2.1.1.1200-03 "Sanitary Protection Zones and Sanitary Classification of Enterprises, Structures and Other Objects").

boundary of the enterprise does not exceed the regulatory established risk level, which is considered to be an acceptable residual risk to health[6]. The legislative enshrinement of the BAT mechanism (Best Available Techniques)[7] to a large extent ensures an acceptable residual risk. The enterprises also pay serious attention to the implementation of special measures to clean air emissions, wastewater treatment, waste recycling, which also contributes to the improvement of the environment in the old-developed regions and reduces the negative impact on public health [7]. While technological and environmental measures are undoubtedly necessary, they should also be recognized as insufficient, especially when it comes to the operation of existing enterprises or their reconstruction, with the introduction of new industrial plants.

Practical experience shows that enterprises are often forced to solve the difficult task of achieving and confirming the acceptability of the residual risk to health, i.e., not exceeding the regulatory value. The situation is particularly acute in the old-developed regions, with historically established fractional building, where the residential areas are in the immediate vicinity of the industrial sites of operating enterprises. In fact, we are talking about the impossibility of reconstruction and modernization, and sometimes even the functioning of the existing production, having in mind the risks of exceeding the regulatory indicators of residual health risk, for example, planned repairs, preventive maintenance works, emergencies, etc. A serious adjustment of the management of industrial enterprises, corporations and industrial groups and their process of decision-making on the development of industrial activity is necessary - not only when selecting a site for new construction, but primarily to ensure the operation of existing production facilities, with the possibility of their reconstruction and modernization in compliance with established environmental requirements.

Determination of approaches, development of specific methods of providing the regulatory level of residual risk to health is a very complex research task. It requires to consider individual disparate techniques of situational response as parts of a single system, with the change of the target orientation of the analysis from purely practical to deep understanding of the issues of ecological safety of human, as the most important recipient of the negative environmental impacts of hazardous industrial facilities. Such comprehension is based on the fundamental context of ensuring the resilience of Human-Dominated Ecosystems [8] changing under the significant influence of hazardous industrial objects.

Without claiming to be an exhaustive implementation of such theoretical concepts, as well as to cover all the relevant aspects of sustainable corporate development, within the framework of the ESG approach[8], these studies were aimed at creating a decision-making algorithm to ensure the environmental safety of the population of oil refining regions based on the mechanism of health risk assessment (hereinafter referred to as the Algorithm). They were conducted over several years, based on the results of numerous design, consulting and research works performed

[6] Recognition that no economic activity can be completely environmentally neutral ("presumption of environmental guilt").

[7] BAT reference book, Decree of the Government of the Russian Federation of December 23, 2014 N 1458 "On the procedure for determining a technology as the best available technology, as well as the development, updating and publication of information and technical reference books on the best available technologies", Art. 3 Federal Law of 10.01.2002 N 7-FZ "On environmental protection", Decree of the Government of the Russian Federation of 24.12.2014 N 2674-p "On approval of the List of areas of the best available technologies ", Decree of the Government of the Russian Federation of 23.12.2014 N 1458 "On the order of technology determination as the best available technology.

[8] ESG is an acronym for Environmental, Social, and Governance. ESG helps stakeholders understand how an organization is managing risks and opportunities related to environmental, social, and governance criteria. Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/knowledge/other/esg-environmental-social-governance/

for Russian oil refineries – both with the specific goal (development of risk-oriented environmental management mechanisms, substantiation of sufficiency of sanitary protection zone boundaries of industrial enterprises and industrial hubs, risk-oriented approach to assessment and reduction of vulnerability of ecosystems and population) and in a broader context of identification and assessment of actual levels of negative environmental impact.

The algorithm is developed as a sequence of actions, covering all stages of the life cycle of an industrial facility/installation. This article provides a description of this algorithm, the detailed content of the stages and procedures of this algorithm application; discusses specific health risk management mechanisms applied at each stage and their practical relevance; substantiates the need for its implementation with corporate management practices.

II. Methods

In methodological terms, the research is based on the provisions of the risk management theory, the conceptual provisions of which, implemented in the ISO 31000 Risk Management series, have been widely used in corporate and governmental management. In general, the risk management process is cyclical and includes the identification of hazards, their sources and created risks; risk assessment and prioritization according to their importance; planning risk management measures (including avoidance, mitigation, and reduction of risks). Regarding the environmental sphere, the risk is defined as the probability of an event having adverse consequences for the environment and caused by adverse impact of industrial and other activities, natural and human-made emergencies (Federal Law dated 10.01.2002 N 7-FZ "On Environmental Protection").

In the field of ensuring public safety from negative environmental impacts, the provisions of the theory of health risks, due to their high social significance and relevance, are now the most regulatory grounded, with normative consolidation in the legislative systems of several countries. At the same time, health risk assessment is considered as a mandatory part of the health risk management process from negative environmental impacts; moreover, it performs the function of monitoring the management process, according to relevant risk indicators (planned, current, regulatory, predictive). From a health and environmental point of view, enterprises are responsible for risk to society and are obliged to share it in proportion to their contribution [9], which is most consistent with the modern perspective of risk management[9], and is the "distribution of possible deviations from expected results and objectives due to uncertainty events, which may be internal or external to the enterprise". This vision of health risk is close to most Russian researchers [10-13].

In accordance with the objectives of this research associated with the limitation of the negative impact of oil refineries on the air, methodological tools were used to assess the risk to public health under the impact of chemical substances polluting the environment, according to the provisions of which are regulated by "Guidelines for risk assessment for public health under the impact of chemical substances polluting the environment" R 2.1.10.1920-04 (approved by the Chief State Sanitary Doctor of Russia 05.03.2004). This document prescribes a sequential (staged) study, including hazard identification, exposure assessment, dose-response relationship assessment, risk characterization. It defines the requirements for the composition and methodology of studies, the data used, and the obligation to perform an uncertainty analysis for each stage. Thus, it sets validation and verification requirements to the results obtained - intermediate and final.

Mathematical modeling of dispersion of average annual concentrations was performed by

[9] By modern perspective of risk management, we mean a comprehensive, integrated and coordinated process within an organization to manage all types of risks it faces.

means of PC "Ecolog", ver. 4.5, calculation block "Averages" ver. 4.5 (Integral, SPb). Calculations of carcinogenic and non-carcinogenic risks were performed using MS Excel 2007 and calculation block "Risks" ver. 4.5, implementing Guide P 2.1.10.1920-04. Cartographic works were performed using a computer geoinformation system (Arc Gis 10.1). The main input data for mathematical modeling were current volumes of "Maximum allowable emissions", sections of "Lists of environmental protection measures" and projects of sanitary protection zones, programs of medium-term development of enterprises. Information about climatic and weather characteristics of the studied territories of oil refineries location was provided by regional division of Russian Hydrometeocenter.

The research is based on the results of a number of projects carried out and currently being carried out for oil refineries located in different geographical zones of Russia. Areas of their location are characterized by specific natural conditions (climatic characteristics, primarily wind and temperature regimes; topography; background condition of atmospheric air, etc.) and socio-economic conditions (urban development situation, proximity and features of the location of residential areas. Specific quantitative indicators in this article (Results) are given according to the results of a project on the implementation of risk-oriented environmental safety management of an oil refinery [14].

III. Results

The Algorithm of making decisions on ensuring environmental safety of the population of oil refining areas based on the health risk assessment mechanism (hereinafter referred to as the Algorithm) is a set of sequential procedures for making reasonable decisions that ensure meeting regulatory requirements for residual health risk to the population exposed to potential negative environmental impacts. The Algorithm illustrates a single iteration (cycle), as part of a continuous process of management of the production enterprise, at all stages of its life cycle, with a special emphasis on those of them, where the level of created health risks is particularly sensitive to the results of decisions made. Each time estimated values of health risk are determined (except for special cases) by the cumulative impact of all objects of the industrial site - existing and new construction.

Stage 1 - Design. Actions are aimed at avoiding additional health risks by making informed design decisions on the master plan in a timely manner. The following actions are included:

1.1 Reasonable choice of location of environmentally hazardous facilities, based on analysis of alternatives. In practice, three alternative locations for the new environmentally hazardous production facility were assessed during the reconstruction project. The most preferable option, with significant financial savings and placement at a site with good logistics and communications, turned out to be blocked by the risk factor (based on the results of a rapid assessment of health risks). The option of placement with a minimum increase in health risk, due to the lack of communications on the site, had unacceptably high financial costs. As a result, the option with an acceptable increase in health risk and acceptable financial costs was taken as optimal.

1.2 Detailed verification of the adopted option of location of environmentally hazardous facilities for compliance with the condition of not exceeding the regulatory level of residual health risk. During the design work, health risks for the adopted option were assessed. The results showed that the regulatory level of residual risk was not exceeded. This result was included in the set of design documents for the reconstruction of the enterprise and served as one of the mandatory conditions for obtaining a positive conclusion of the state environmental expertise.

Stage 2 - Construction. The construction process, due to its technological specifics, does not pose significant risks to public health and is short-term in nature.

Stage 3 - Operation. The actions are aimed at reducing the likelihood of occurrence and minimizing damage from the risk by assessing health risks, determining the priority (in terms of the value of generated risks) of the areas of sanitary protection zone boundary and industrial sites, production facilities and chemical toxicants. A set of actions includes the following:

3.1 Identification of the most hazardous areas of the sanitary protection zone and the industrial site, priority facilities and chemical toxicants (in terms of the magnitude of the created risks). During the analysis of riskogenic situation at the enterprise it was revealed that the most dangerous parts of the sanitary protection zone boundary are in the southern and north-eastern directions. The most hygienically significant receptor points are concentrated in these parts of the sanitary protection zone boundary. The areas of the industrial site that create the most significant impacts are localized in these directions. As the detailed analysis showed, even if the orientation and configuration of non-carcinogenic risks distribution (in the shape of oval with orientation to the northwest) is preserved, the introduction of new facilities expands the area of risk distribution. The results of the geographical orientation of the risk fields located within the sanitary protection zone boundary and correlated with the general plan of the enterprise (as applied to the task of new construction facilities location) show that it is unacceptable to locate new production facilities in the north-western part of the industrial site.

The priority riskogenic production facilities are: among the new construction objects - hydrocracking unit and sulfur production unit; among the existing facilities - unit 35-11 / 300-2, unit L-24-T-6, unit L-24-200-86. A detailed analysis showed that the highest priority is given to the new construction sites - hydrocracking unit (14.5%) and sulfur production unit (contribution - 13.8%); the existing facilities are rated approximately at the same level - distillation unit ELOU-AVT-4 (contribution - 3.2%), automated light oil products cycle loading unit with a vapor recovery unit (contribution - 2.6%) and tar visbreaking unit (contribution - 2.1%).

The list of priority risk-generating chemical toxicants (the most dangerous, with non-carcinogenic and carcinogenic properties) included 11 items (out of 27 pollutants identified at the facility), including 11 non-carcinogenic substances (sulfur dioxide, sulfur dioxide, hydrogen sulfide, kerosene, nitrogen oxide, vanadium pentoxide, xylene, benzene, carbon black, benzo/a/pyrene, ethylbenzene) and 4 substances with carcinogenic effect (benzene, carbon, ethylbenzene, benzo/a/pyrene).

3.2 Adjustment of industrial control and industrial environmental control programs based on the results of riskogenic situation dynamics. Based on the results of the analysis of risk priority of the sanitary protection zone boundary areas, production facilities and chemical toxicants (clause 3.1), the programs were adjusted in terms of measurement locations, measurement schedules and lists of controlled substances. In particular, control points where the maximum risk load is formed were selected, including: at the sanitary protection zone boundary and at the boundary of residential development / the boundary of regulated areas, taking into account the location of sections of the industrial site where the greatest risks are created, as well as installations with the greatest contribution to the total risk indicator. Changes were made to the sampling schedules: for each new construction facility, within the first year after commissioning, the number of days of testing for the full list of characteristic toxicants was determined. The list of analyzed substances in the control points was corrected - priority risk-generating toxicants were included (non-carcinogens - sulfur dioxide, nitrogen dioxide, nitrogen oxide; carcinogens - benzene, carbon; as well as pollutants specific to the enterprise: kerosene, hydrogen sulfide, vanadium pentoxide, xylene).

3.3. Refinement of plans for the implementation of investment measures (including environmental protection facilities), considering the potential to reduce the level of health risk for each facility. As practice shows, measures to prevent losses of commercial products, such as the construction of a unit for sealed loading of oil products into rail tank cars, have a high potential to reduce health risks compared to even targeted environmental protection measures.

3.4 Specification of technical operational documentation, in order to minimize the probability of exceeding the regulatory level of residual risk to health of the population (carrying out commissioning, repair work, maintenance, etc.). In practice, this means reducing the probability of exceeding the regulatory level of residual risk to health, with strict compliance with technological standards and standards of industrial safety, for example, by minimizing short-term salvo emissions of priority chemical toxicants by diluting in time and by localization at the site of the corresponding sources of emissions (during repairs, maintenance, etc.).

3.5 Ensuring compliance with the established regime of using the territory of the sanitary protection zone. Practice shows the effectiveness of such measures as preventing the placement of industrial and civil facilities that pose a threat of exceeding the regulatory values of health risks at the sanitary protection zone boundary; eliminating existing and preventing potential unauthorized waste dumps; landscaping and planting of the area.

Stage 4 - Decommissioning. In the case of termination of operation, liquidation (including demolition) of the object there are no standard actions within the framework of the management of health risks.

IV. Discussion

The results of the research on the development and testing of the decision-making algorithm to ensure environmental safety of the population of oil refining areas on the basis of the health risk assessment showed its feasibility and high efficiency both in terms of compliance with applicable legal requirements, and in the aspect of sustainable business development in accordance with ESG-approaches. Testing at a number of oil refineries showed that actions within the Algorithm, due to the application of the health risk assessment, allow to ensure compliance with the regulatory indicator of residual health risks at the sanitary protection zone boundary. At the same time, the monitoring of the current indicators of health risks, with the analysis of the dynamics, in comparison with the regulatory values, is an indispensable and recurring element of many actions. Health risk management is implemented by the following tools:

At the design stage: risk avoidance, as a result of (1) a reasonable choice of location of new facilities at the industrial site of the existing enterprise, (2) reasonable planning decisions on the placement of environmentally hazardous production facilities at the industrial site of a new enterprise; reduction of health risk by reducing the potential damage and/or reducing the probability of risk realization, as a result of the use of technologies whose environmental impacts meet the BAT level, as well as effective.

During the operation stage: reduction of health risk by decreasing the likelihood of risk occurrence, as a result of improving the effectiveness of systems of industrial and environmental control (clarifying the location of measurement points, measurement schedules, controlled substances); decreasing of health risk by reducing the potential damage and/or the likelihood of risk execution, as a result of (1) changing the priority of investment activities, including environmental protection; (2) specification of operational requirements to minimize the level and probability of riskogenic emissions by minimizing the duration of simultaneous operation of environmentally hazardous installations, separation of maintenance and preventive work by time and location at the industrial site, etc.; (3) ensuring compliance with the established regime of using the sanitary protection zone, primarily by preventing the placement of industrial and civil facilities that pose a threat of exceeding the regulatory values at the sanitary protection zone boundary.

The relevance of the Algorithm is associated with the need to abandon the previously established practice of planning decisions (the initial stage of design - decisions on the general plan), guided primarily by economic and technological considerations, while actually ignoring the environmental aspects of the functioning of future facilities (including health risks). This leads to a violation of environmental legislation, with appropriate economic and reputational sanctions. One should also consider the low environmental performance of environmental protection measures at the stage of operation, which is limited already at the construction stage by the selected technologies and localization of sources of pollution of emissions and discharges of pollutants [15].

The algorithm is universal. It can be used for existing production facilities and new construction projects, as part of the reconstruction and modernization of enterprises. It is also effective in the implementation of investment projects for the construction of new industrial enterprises. The sphere of its application is not determined by industry specifics - it can be used in the management practice of any enterprise or industrial company, first of all, those which have environmentally hazardous production facilities. Finally, the logic of the Algorithm and the sequence of actions are relevant not only in relation to chemical pollution of atmospheric air, but also in situations of health risks from acoustic and electromagnetic effects, from contamination of water.

In general, it should be emphasized that, in accordance with the logic of risk management, health risks created by the enterprise should be integrated into the overall risk management system of the enterprise (along with the risks of industrial safety, financial, operational, climatic risks, etc.). It is obvious, that within the framework of the enterprise risk management system, created health risks can be identified as a risk of non-compliance with the established legal requirements in the field of environmental safety of the population. Nevertheless, there is no doubt that indicators characterizing the risk-posing capacity of the enterprise for the population should be included in the decision-making process in risk management, strategic planning, current operational management and financial planning.

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